SCIENTIFIC RESEARCH IN THE OVERSEAS TERRITORIES OF THE BRITISH COMMONWEALTH

IN a recent book, "The End of Empire"*, Mr. John Strachey argues cogently that Britain has a unique opportunity to lead the world in meeting the needs of the under-developed peoples and that, in doing so, in supplying both material means and technical skills, she can rise to a new level of national greatness. Mr. Strachey does not enter into any detail as to how this is to be done, and only passing reference is made to the Colombo Plan, the Colonial Development Corporation and the Colonial Development and Welfare Funds. Much stress is, however, laid on the replacement of the old conception of 'Colonial' by something wider, perhaps even wider than that of 'Commonwealth', though Mr. Strachey readily admits that the idea and the structure of the British Commonwealth offer possibilities of genuine advance.

From this point of view alone there is much to be said for the creation of the Overseas Research Council, though it is all the stranger that it should have been left for a question in the House of Commons to elicit the statement that the Colonial Research Council was dissolved in August 1959, and that its functions as an advisory and co-ordinating body now fall to the Overseas Research Council, which is responsible to the Minister for Science and operates in relation to overseas research generally. This was stated by Mr. Ian Macleod, Secretary of State for the Colonies, on March 10, and accordingly it would seem that "Colonial Research 1958–59"†, which includes the report of the Colonial Research Council on Colonial research during the year 1958–59, along with the reports of the several specialist advisory bodies and one on research matters not covered by their reports, is the last to appear from the Colonial Research Council. Although, however, the covering letter submitting the report is dated November 4, 1959, no reference is made in any of these reports to the change, nor is any indication given as to the proposed future policy in regard to publication.

It would be difficult, however, to over-stress the importance of the work which has been briefly described in the reports collected under the general title "Colonial Research" during the past decade, and comments recently made by Dr. B. V. Bowden, principal of the Manchester College of Science and Technology, in two articles in *The Guardian* of March 9 and 10 dealing with his recent visit to Ghana, show how important it is both that such work should receive effective publicity and also that research work should be stimulated on an adequate scale in the university and technological institutions of the overseas territories before and after they achieve independent status. Dr. Bowden's articles show that the importance of research is as yet far from being understood in these emerging nations, or the contribution it can bring to the solution of their problems. The research schemes supported from Colonial Development and Welfare Funds and the research branch of the Overseas Civil Service may well increase rather than decrease in importance during the next decade.

The schemes noted in the present report—71 new schemes and 63 supplementary—involve grants totalling £798,974 and bring the total allotted to Colonial Development and Welfare Research Schemes since 1940 to £19,493,932; actual disbursements now total nearly £14·7 million. Much the largest research schemes approved during the year ended March 31, 1959, are those for the Tropical Section of the Road Research Laboratory (£121,568), the Colonial Pesticides Research Unit, Arusha, East Africa (£71,188) and the maintenance of the Anti-Locust Research Centre, 1958–59 (£65,657); £31,405 was for trachoma research, 1958–60; £23,372 for the Desert Locust Survey; £39,524 for the Tropical Metabolism Research Unit, Jamaica; £22,728 for agricultural research in Swaziland; some £31,000 for the West African Building Research Unit; £19,440 for the Colonial Microbiological Research Institute, Trinidad; £20,226 for the Seismic Research Unit in the Imperial College of Tropical Agriculture, Trinidad; £15,825 for the establishment of a cocoa research station in the British Solomon Islands Protectorate; and £15,000 for sorghum breeding research in East Africa. While no other research grants exceeded £15,000, these examples sufficiently indicate the vital importance of continued support from the United Kingdom, both in respect of the nature of the schemes and the financial resources of the territories concerned, even when due regard is had to the assistance already given by the Colonial governments from their own resources.

It is obvious from these figures that the research schemes represent a relatively minor proportion of the assistance already being given to the lesser developed countries from British Government funds. The White Paper "Assistance from the United Kingdom for Overseas Development"* put the total at £138 millions in the current year alone, an increase of £57 million on 1957–58, and although the former sum represents about 1·25 per cent of the national

* The End of Empire. By John Strachey. Pp. 351. (London: Victor Gollancz, Ltd., 1959.) 30*s.* net.

† Colonial Office. Colonial Research 1958–1959: Reports of the Colonial Research Council; Committee for Colonial Agricultural, Animal Health and Forestry Research; Colonial Economic Research Committee; Colonial Fisheries Advisory Committee; Colonial Medical Research Committee; Colonial Pesticides Research Committee; Colonial Products Council; Colonial Road Research Committee; Colonial Social Sciences Research Council; Tsetse Fly and Trypanosomiasis Committee; Director, Anti-Locust Research Centre; and Research Matters not covered by the above Reports of the Specialist Advisory Bodies. Pp. 419. (Cmnd. 938.) (London: H.M. Stationery Office, 1959.)

* "Assistance from the United Kingdom for Overseas Development." Cmnd. 974. Pp. 19. (H.M.S.O., 1960.) 1*s.* net.

income of the United Kingdom, the White Paper urges the need to continue and if possible increase this effort. It may well be that the proportion going to research schemes is the one that, apart from educational assistance, most urgently needs increasing and, as already suggested, the need may become even more urgent as the Colonial territories achieve independence. About 33 per cent of the gross allocation of Colonial Development and Welfare Research Funds has been for agricultural, animal health and forestry schemes, 17 per cent for medical research, 9 per cent for fisheries research, 10 per cent for tsetse and trypanosomiasis research, 8 per cent for social science and economic research, 9 per cent for pesticides research, 5 per cent for research sponsored by the Colonial Products Council and 3 per cent for anti-locust research. Frequently such research involves the co-operation of research institutions and organizations working in several territories, and it may not be easy for a newly independent territory always to appreciate the significance of such work or the factors determining its success. A similar observation might be made of some of the work described in the section of "Colonial Research" which deals with research matters not covered by the reports of the specialist advising bodies. Building and housing research, for example, largely relies on the work of the Tropical Building Section of the Building Research Station of the Department of Scientific and Industrial Research in Britain. The Geodetic and Topographical Surveys and the Geological Surveys as well as meteorological research also depend largely on assistance from the United Kingdom, and although in East Africa there is a flourishing Industrial Research Organization, elsewhere the Crown Agents' Engineering Advisory Service assists and advises overseas officers on a wide range of technical matters; reference is also made particularly to advice given overseas by the Water Pollution Research Laboratory.

In much of this work man-power is an important factor. Twenty-five new appointments brought the total complement of the Research Branch of the Overseas Civil Service to 207 in March 1959. There was also a Research Fellow studying nematode damage on East Africa crops, who completed his investigations during the year, and a second continuing work on human trypanosomiasis at the West African Institute for Trypanosomiasis Research; two further Research Fellowships were awarded for work at the University College of the West Indies as well as two research studentships in medicine and one in soil science for training for research appointments overseas.

Measured against the tasks still to be undertaken, let alone completed, this man-power seems slender even when allowance is made for the substantial contribution made by British universities and the staffs responsible to the several research councils such as the Council for Scientific and Industrial Research, the Medical Research Council and the Agricultural Research Council. The question of man-power is undoubtedly one of the most important which the Overseas Research Council will have to face, and it should be able to count on the full support of the Advisory Council for Scientific Policy, perhaps the more especially since the recent inquiry into scientific and engineering man-power in Great Britain conducted for that Council by its Committee on Scientific Man-power made no estimates of the demand for such man-power overseas. The proceedings of the Commonwealth Education Conference again show how important it is that the overseas need should receive full attention in planning the expansion of university and of technological education.

In this context the new Overseas Research Council will require to work in close association with the Scientific Council for Africa South of the Sahara and with the Commission for Technical Co-operation in Africa South of the Sahara. The recently published report of the tenth meeting of the Scientific Council* gives no indication of the resources at the disposal of either the Council or the Commission; but, quite apart from the extent to which many problems in Africa depend on international co-operation for their solution, it is obvious that every effort should be made to avoid duplication of effort, and to use the limited resources of scientific and technical man-power as wisely as possible and where the maximum advantage to the general benefit can be obtained. Reference is already being made to the increasing difficulty in co-ordinating agricultural research projects, for example, owing to the speed of developments in Africa, and only international action can hope to solve the problems raised by the destruction of natural resources in Africa.

There are indeed signs that co-operation is developing. An Inter-African Conference on hydrology is to be held at Nairobi in January 1961, and the Inter-African Pedological Service, which was expected to be fully staffed by the autumn of 1959, reports progress with the pedological map of Africa except in West Africa. The Inter-African Soils Bureau is directing its activities more towards liaison between technical organizations working in Africa and is seeking to play a more dynamic part. Inter-African Conferences on Soils and on Forestry have already been held, and the Food and Agriculture Organization of the United Nations intends to set up in Africa a regional forestry commission as in other continents. Other examples are to be seen in the Inter-African Bureau for Epizootic Diseases, the function of which in examining requests for technical aid in the field of animal diseases is likely to develop in future, the Inter-African Conferences on Housing and Urbanization and on Labour, of which two and six, respectively, have already been held, and the Inter-African Committee on Maps and Surveys.

One note of caution should be sounded in respect of any developments depending on the Scientific Council for Africa South of the Sahara. Among the participants are the Union of South Africa, which indeed supplies the present chairman in the person of

* Scientific Council for Africa South of the Sahara. Publication No. 37: Tenth Meeting of the Science Council, Kampala, 1959. Pp. 135. (London: Secretariat, C.C.T.A./C.S.A., Abbey House, Victoria Street, 1959.)

Dr. P. S. du Toit, and Dr. S. M. Naudé as an ordinary member. Recent events in South Africa and the general policy of the South African Government must make it more than doubtful whether the continued support of that Government can be expected, and even whether its membership of the Council will continue to be acceptable to other countries. The ultimate effect of the South African Government's policies towards the universities and eventually to scientific research is likely to stultify the value of much of its contribution.

The picture of co-operation provided in "Colonial Research 1958–59" is much more reassuring. Much the longest of the reports of the ten specialist advisory bodies is that of the Committee for Agricultural, Animal Health and Forestry Research, which occupies more than 170 pages out of a total of 419. Besides stressing the importance of the work being done by the Commonwealth Institute of Entomology, the Commonwealth Institute of Biological Control, the Commonwealth Mycological Institute and the Department of Statistics at the Rothamsted Experimental Station, this report deals at length with the work of various regional organizations such as the East Africa Agriculture and Forestry Research Organization, the East Africa Veterinary Research Organization and the West African Cocoa Research Institute. The much shorter reports of the Colonial Fisheries Advisory Committee and the Colonial Social Science Research Council are likewise much concerned with the work of regional bodies. But the report of the Colonial Pesticides Research Committee, by and large, depends on the work of such co-operative ventures as the Colonial Pesticides Research Unit at Porton, the Agricultural Research Council's Unit of Experimental Agronomy at Oxford, the Silwood Park Field Station of the Imperial College of Science and Technology, the Colonial Pesticides Research Unit, East Africa, and the West African Fungicides Team.

The bulk of the work of the Tsetse Fly and Trypanosomiasis Committee is carried out through the East African Trypanosomiasis Research Organization and the West African Institute for Trypanosomiasis Research, while that of the Anti-Locust Research Centre on locust research and control is peculiarly dependent on political factors which may retard or favour international co-operation. This year's report refers to a notable tendency to expand and strengthen international co-operation both in locust control and in these lines of research which provide a basis for practical anti-locust measures. The Director refers appreciatively both to the help given by the Food and Agriculture Organization, the United Nations Educational, Scientific and Cultural Organization and the World Medical Organization, and to progress made in research on problems of locust biology.

In such conditions it is impossible for scientific and technical research on problems of the Colonial or Overseas Territories to disregard entirely the political situation, at least so far as it affects the conditions in which scientific and technical work is pursued. It would indeed be wrong if scientists and technologists failed to make representations when particular policies threaten the conditions in which creative work, effective co-operation between scientists and technologists of different nationalities or races, or the free interchange of scientific and technical knowledge, are possible. "Colonial Research 1958–59" provides an impressive picture of the effort which is already being made in Great Britain to serve the Overseas Territories, whether dependent or independent. But there is no room for complacency; expansion is an urgent need. It is the more important, therefore, that the political conditions which determine its efficiency and effectiveness should be clearly understood, and that government policies should be such as to encourage and not hinder or frustrate the essential co-operation and the creative work which have so much to bring to the welfare and development of the less advanced peoples.

MODERN PHILOSOPHY OF SCIENCE

Modern Philosophy of Science

Selected Essays. By Hans Reichenbach. Translated and edited by Maria Reichenbach. Pp. ix+214. (London: Routledge and Kegan Paul, Ltd.; New York: Humanities Press, 1959.) 28*s*. net.

THIS book contains eight articles by the late Prof. Hans Reichenbach, only one of which has previously appeared in English. Five are translated from earlier appearances in German, and two, concerned with the ethical problem, are compiled from MS. notes left by the author. The translation and editing have been carried out by the author's widow, Mrs. Maria Reichenbach, and there is a short foreword by Prof. R. Carnap. A valuable feature of the book is a complete bibliography of Reichenbach's writings which is appended.

Reichenbach was one of the founders of the logical-empiricist school of philosophy which came into being mainly through the philosophical implications of the theory of relativity, and throughout his life he remained one of its ablest and clearest expositors. Anything from his pen is worth reading. Nevertheless, it is doubtful whether the present volume was a well-advised venture. Much of the material has been incorporated in better form in work published by Reichenbach during his lifetime, and some of the remainder—particularly the first essay, which replies to some early objections to relativity—is no longer of vital interest. The immediate philosophical reaction to the relativity theory was the charge that it violated certain fundamental philosophical principles and therefore could not be true. This is now generally acknowledged to have been due to a misunderstanding. It is clear that, so far as such principles are concerned, the theory could be true: the important question now is whether it is true. The criticisms which Reichenbach set out to answer in 1921 have long ceased to trouble anyone.

The essay on "The Freedom of the Will", together with a short note on "The Explication of Ethical Utterances", constitute the part of the book not previously published. This was well worth issuing, for it presents in more detailed form ideas already

adumbrated in "The Rise of Scientific Philosophy", published in 1951. The thesis maintained is that while determinism excludes complete freedom of the will, probabilistic causality does not, and a "non-cognitive theory of ethics" is advanced of which the essence is "the recognition of the non-logical relation between knowledge and action". This is consistent with the author's general philosophy of science, of which "The Rise of Scientific Philosophy" gives an admirable account. Owing to the much more speculative nature of the subject, however, it is scarcely likely to carry the same conviction as the epistemological discussions which are more directly related to the actual content of modern physical theory.

HERBERT DINGLE

SOCIOLOGY: THE NEW HOPE

The Sociological Imagination

By C. Wright Mills. Pp. vii+234. (London and New York: Oxford University Press, 1959.) 36*s*. net.

THIS book has, in effect, three themes: (1) a sociological account of the present state of the social sciences themselves, and particularly of the state of sociology in the United States; (2) recommendations concerning what the social sciences should be like, and finally, (3) reflexions on our times. The three themes are, of course, closely interwoven, for the account of current sociology is largely a condemnation which calls for a specification of a better way, while the diagnosis of how the ills came about requires a discussion of the wider social factors responsible for them.

At the root of sociology and the social sciences lies a great hope and a promise—of a kind of collective self-knowledge. If there is one thing which ought to be obvious (though there are still people to whom it is not) it is that society constrains us, that our lives, thoughts and aims are, at the very least, conditioned by a social framework we never made or chose, and in a way we often do not understand. Sometimes, and for those fortunate enough to be in a congenial environment, this is no source of sorrow: but when the insight is combined with a partial rejection or failure of current values and institutions, it leads to a hope of control through knowledge. This hope, as Prof. Mills reminds us, was at the origin of sociology, and it still powerfully animates him—if not all his colleagues.

If there is one country where this hope might be thought to have better expectations of fulfilment than elsewhere, it is the United States, where sociology is a recognized and extensive profession, where it is neither muzzled (as it is behind the Iron Curtain), nor ignored as the dubious fad of a marginal minority. In fact, the picture in the United States is not at all rosy, despite the number of sociologists and the recognition they receive. Prof. Mills provides an explanation, and he does it brilliantly.

A good deal of the output of the flourishing American sociological profession consists, using Mills's terms, of "Grand Theory" or of "Abstracted Empiricism". "Grand Theory", not to put too fine a point on it, is simply pretentious verbiage of a kind which has to be read to be believed. Prof. Mills charitably says that it does contain some ideas, and heroically extracts them for us. The respectable mice rescued from under the mountains of rubbish are insights—valid so far as they go and well suited for any systematic treatment of societies—such as that social life consists of the interaction of individuals with reasonably stable reciprocal expectations, with shared values which had been inculcated by a common background, and so forth . . . (but not for very long, for this is nearly all there is in it).

"Abstracted Empiricism" consists of the proliferation of ritualized, standardized surveys, usually by means of questionnaires, in which the collection of dubiously valuable or even reliable data is guided by little thought or concern with genuine questions. The blindness of such "Abstracted Empiricism" complements the emptiness of "Grand Theory".

Prof. Mills gives us a convincing account of how these fashions came to be dominant. Their roots are various: the emulation of a false image of natural science, an image which was mistaken anyway, and which in any case, even if it were valid, could not be easily re-applied to social matters; the shift of the practical impulse from, roughly speaking, helping the poor to helping sales promotion and the manipulation of personnel; the safe political innocuousness of the new practices; the (probably inevitable) bureaucratic ethos inherent in the administration of foundations, expensive and large-scale research, etc. (Natural scientists are fortunate in that the traditions of their subject were well established before our present era. One shudders to think what might have happened had the foundations existed in the early days of the Royal Society.)

Prof. Mills attempts to do more than describe and analyse the current ills, he also hopes to remedy them. His recommendations to sociologists are sound and perceptive. So are his reflexions on our times and the part that thought and valuation can play in the modern world. I only fear that he may implicitly—in trying to stem the tide—be too optimistic, that the general social factors on the other side are too strong. I hope I am wrong.

But this is not a book which will stand or fall by either the soundness or the success of its positive recommendations. It is already fully justified by the admirable account offered of an important if unattractive phenomenon, and one which is playing a very significant part in American life. This was, so to speak, a necessary book. Somebody had to write it, and we can all be thoroughly grateful that the somebody was Prof. C. Wright Mills.

E. GELLNER

DAIRYING IN GREAT BRITAIN

The United Kingdom Dairy Industry

Edited by Prof. E. L. Crossley. (Prepared under the auspices of the XV International Dairy Congress on behalf of the United Kingdom Dairy Association.) Pp. viii+142+16 plates. (London: United Kingdom Dairy Association, 1959.)

THIS book was written to mark the fifteenth International Dairy Congress held in London during the summer of 1959; it provides a valuable picture of the state of the dairy industry in the late fifties. Prof. E. L. Crossley, helped by a list of distinguished contributors, has distilled 142 remarkably uncluttered pages of useful information. He begins by setting dairying in relation to other branches of agriculture and reminds us that milk and dairy

products worth no less than £350 million are produced annually on British farms. This forms about one-third of the total agricultural output and represents almost twice as much milk as was produced for sale in 1935, or is produced at the present time in such major dairying countries as Denmark, the Netherlands and New Zealand. Further, the annual increase in milk production has also been considerably more rapid than in most other dairying countries.

From the economic structure of the industry we pass to milk production on the farm and the astonishing changes which have taken place since 1935 in the national herd, in milk recording, in artificial insemination, in the feeding and management of cows and in the design and use of cowsheds and milking machines. Nor are the advisory services, the necessary milk regulations and the means of controlling milk quality overlooked.

About two-thirds of the book is devoted to dairying in its narrower sense, to milk collection, transport and reception, to pasteurization, sterilization and bottling of milk, with all the machinery these involve to-day, to some essentially British aspects of milk distribution and to the control of milk quality at every stage. Naturally we find also an account of the development of a highly efficient dairy technology from the traditional farm-house manufacture of cream, butter and cheese.

The book concludes with chapters describing the training of young people for the dairy industry and outlining the work now in progress at the main centres of research. For readers who find here a new or wider interest in dairying—and they will certainly number more than the overseas Congress visitors at whom the book was modestly aimed—there is a useful list of general information. This provides a ready means of following any topic in greater detail. There is also an abundance of good illustrations ranging appropriately from attractive coloured drawings of the breeds of dairy cattle to most appetizing pictures in beautiful colour of the industry's greatest triumph, British territorial cheeses at their best.

C. C. Balch

CENTRAL AFRICAN SAVANNAHS

Les Savanes de l'Afrique Centrale

Essai sur la Physionomie, la Structure et le Dynamisme des Formations Végétales Ligneuses des Régions Sèches de la République Centrafricaine. Par Roger Sillans. (Encyclopédie Biologique, Tome 55.) Pp. xv+424+2 planches. (Paris: Éditions Paul Lechevalier, 1959.) 16,000 francs.

In spite of the wider geographical implications of the title, this book relates directly only to the territory of Oubangui-Chari, which with the Cameroons and Moyen Congo to its west, and the Sudan to its east, is, from its central position in tropical Africa, of more than usual importance for considering questions of plant-geography. Based on a doctoral thesis by R. Sillans, it is primarily a record of personal observation and study of the savannahs of that part of Africa, and more especially of their woody vegetation.

The contents of this book follow an arrangement not unusual in studies such as these, with descriptions of climate, geography, geology and soils, and a general account of the ecological classification of the vegetation of Oubangui-Chari, followed by a discussion of the methods employed by the author and some of the terms used. After this preliminary matter there is a much more detailed account of the savannah vegetation, together with a floristic list of the known woody species.

The territory shows a range of vegetation from lowland rain-forest to woodland and savannah, spread over a rather uniform topography, and accompanied by gradual climatic changes. As the author suggests, there are no natural frontiers to the territory. In all, some 3,600 species occur, among which are a number of endemics of which the author gives a list. This, however, needs some revision: for example, *Cola gigantea* is not endemic, and the remarkable Bignoniaceous genus *Tisserantodendron* occurs also in the Cameroons. The author also attempts to give a biological spectrum of the flora.

That part of the work of most general interest deals with the author's conclusions about how the vegetation has evolved. He maintains that the original covering of forest or woodland has been and is still being destroyed by means of clearing for the purpose of subsequent cultivation. Repeated through the centuries, this clearing, accompanied by partial or complete felling and by firing of the resultant débris, has entailed modifications in vegetation, species, soil and, perhaps, climate. The forest is replaced by tall grassland with more or less scattered trees, which may itself develop into savannah-woodland and ultimately, perhaps, again into forest. The savannahs of Oubangui-Chari in fact represent, according to the author, various stages in seral regeneration following cultivation.

Now, according to Sillans, the original regression of the forest is in no way due to bush-fires; not until cultivation has resulted in the establishment of grassland can they enter. He considers that their destructive effect has been over-estimated, and that they do not normally prevent a gradual re-development of savannah woodland into forest. No evidence of real adaptation of plants to a permanent régime of fires is regarded by him as proved; but there is an interesting account of nanism and the 'suffruticose' habit being induced in a species of *Bridelia* through repeated cutting in connexion with cultivation.

The problems of the age and origin of bush-fires and their effect on the savannah vegetation of tropical Africa are still most disputed; in fact Prof. J.-L. Trochain, in a preface to the book, combats some of M. Sillans's views. The ultimate solutions are, however, brought nearer by the important evidence presented in this work. I am, however, appalled by its price of 16,000 francs. J. P. M. Brenan

UNSTEADY SUPERSONIC FLOW

The Potential Theory of Unsteady Supersonic Flow

By Prof. John W. Miles. (Cambridge Monographs on Mechanics and Applied Mathematics.) Pp. xii+220. (Cambridge: At the University Press, 1959.) 45*s*. net.

The aerodynamic theory of unsteady flows is mainly concerned with questions of the following type: If a wing or body, moving forward with constant speed, has a prescribed transverse motion about its rectilinear mean path, what are the resulting forces and moments? During the golden age of the linearized theory of compressible flow (1945–55 approximately), when it was permissible to assume

that wings were thin, Mach numbers moderate, and disturbances small, a considerable store of answers to such questions was established. Prof. Miles was very much in the forefront of the attack on these problems, and the appearance of his authoritative book on the subject is to be welcomed.

The book deals mainly with the supersonic theory, in which the existence of domains of influence and dependence makes it possible to solve explicitly a number of linearized problems. The opening chapter is a careful study of the restrictions appropriate to various approximate governing equations, of which that corresponding to the sound equation in still air is the most important: various xt-transformations (x is the streamwise co-ordinate, t the time) of this equation are then considered. Basing his presentation not on the traditional method of retarded-potential doublets but on the more compact method of integral transforms, Prof. Miles makes short work of each of the following problems: two-dimensional wings, the rectangular wing of semi-infinite span, wings with 'supersonic' edges, and the extension of Evvard's method to wings with straight, subsonic side-edges. For the delta wing with subsonic edges, further approximations are necessary. There is a detailed account of methods for wings of slender planform and slender bodies, and the book ends with a genuflexion towards non-linear problems.

Despite the formidable economy of his presentation, the author cannot treat all the ramifications of his subject in a book of modest size, but there are ample references to papers on those (mainly secondary) questions which are not included. The book maintains the high standard of the Cambridge Monographs on Mechanics and Applied Mathematics.

L. E. Fraenkel

MONKEYS AND DISEASE

Diseases of Laboratory Primates

By Prof. Theodore C. Ruch. Pp. xxvi+600. (Philadelphia and London: W. B. Saunders Company, 1959.) 52*s*. 6*d*.

THIS volume is the first of four parts of a projected "Handbook of Primates", and treats in monographic form the spontaneous diseases of laboratory primates. The main topics reviewed are the diseases caused by parasitic agents and, to a lesser extent, nutritional disorders, both of which have an important bearing on the management of a monkey colony. In addition to this information, which is of immediate practical value, the author also describes the nature of conditions such as cardiovascular and dental diseases and suggests that monkeys may be suitable animals for research into these problems.

Three of the more important conditions—enteric diseases, respiratory tract infections and tuberculosis—which are responsible for the high mortality frequently observed in monkeys, are dealt with at length. The chapters on these subjects will be of particular interest to those who are responsible for the management of large colonies of monkeys now maintained in many countries for the production and testing of poliomyelitis vaccine.

In the course of reading this book, attention is directed to the numerous pathogenic agents which have been accidentally transmitted to man. Of these the most serious is *B*-virus (*Herpesvirus simiae*), which has caused a number of fatal cases of ascending myelitis. Since this virus, and other pathogenic agents, are localized in the mouths of infected animals, the author rightly points out that procedures should be designed to preclude, so far as possible, the occurrence of monkey bites. It would have been of value to those who have not seen this condition in monkeys if photographs showing *B*-virus lesions in infected animals had been included.

The compilation of this volume is clearly the result of much painstaking work involving an extensive review of literature and, in addition to providing factual material, Prof. Ruch has succeeded in presenting the subject-matter on each topic in a most readable form. This will be a very useful reference book and its publication fills an important gap in scientific literature.

C. R. Coid

THE MEASUREMENT OF INFORMATION

Information Theory and Statistics

By Prof. Solomon Kullback. (Wiley Publications in Mathematical Statistics.) Pp. xvii+395. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1959.) 100*s*. net.

THIS book provides a treatise upon the general statistical theory of information, as complete, thorough and up to date as any single book to-day. It deals with the various measures of information and information-rate, not restricted to their place within the theory of communication (as are so many recent texts), but as part of the general theory of statistics and probability. It covers and relates the work of Fisher, Shannon, Chernoff, Kolmogorov, of Good, Woodward, Barnard and many others well known within the field.

The author's reputation here needs no comment from me. In this book he aims at unification—conceptual, notational and methodological—of scattered work by West Europeans, Americans and Russians too. He covers not only the specialized applications of information theory to communication problems but treats the whole field of statistical hypothesis testing as it arises also in the design of experiments and in observation theory, in the theory of stochastic processes, in parameter estimation and in other processes of statistical inference. In the first half of the book the various logarithmic measures of information are developed and their properties studied, in terms of measure theory; it is the second half which is concerned with a wide range of applications to statistical inference.

The book is essentially mathematical in treatment and in its purpose. It comes at an opportune time for many people in the physical sciences; for biologists, for telecommunication engineers (detection, coding problems, etc.); again, for psycho-physics (behaviour models and artefacts) and many other fields. Modern techniques of statistical inference are making an ever-increasing contribution and the relevance of information theory merits careful attention and revaluation at this present time.

The many worked and unworked examples form a particularly valuable feature of the book; it is well provided, too, with a glossary of mathematical terms and with a comprehensive bibliography of several hundred references.

Colin Cherry

Rice

By D. H. Grist. Third edition. (Tropical Agriculture Series.) Pp. xxiii+466+72 photographs. (London: Longmans, Green and Co., Ltd., 1959.) 48*s*. net.

D. H. GRIST'S valuable book "Rice" is now in its third edition. It has been strengthened by the inclusion of two authoritative chapters, one on the genetics of rice and the other on improvement by selection and breeding. These were contributed by D. Rhind, who has had the satisfaction of seeing in West Africa progeny of seed he bred in Burma. Grist also has spent much of his life in the study of this crop and is to be congratulated both on the original compilation and on the no less important revision. In Chapter 12, Grist quotes the work of Pearsall and Mortimer (*J. Ecol.*, 27, 483; 1939) and of Pearsall (*Emp. J. Exp. Agric.*, 18, 289; 1950) which, he points out, provided an entirely new approach to the chemistry of water-logged soils. The Japanese quickly followed up these ideas, leading to more efficient use of their hard-pressed paddy fields. It is hoped that it will be possible for Grist to enlarge this chapter in the next edition of this book so as to include an account of this recent work.

H. GREENE

1959 Supplement to British Veterinary Codex 1953

Pp. xviii+134. (London: Pharmaceutical Press, 1959.) 35*s*.

THE appearance of this Supplement to the British Veterinary Codex is an expression of the policy of the Codex Committee to provide an interim volume before proceeding to a full new edition. It is a sound policy, and a necessary one, if the Codex is to attempt to keep abreast of new developments in the field of pharmacology. The drugs and vaccines described in the Supplement are already familiar by their having been some time in veterinary use, and it becomes a welcome reference book on actions and dosage. The period since the first appearance of the British Veterinary Codex in 1953 has been one of intensive research in pharmacology, and it is, indeed, during this period that a specific discipline of veterinary pharmacology has emerged. Curiously enough, despite these exciting new developments, the teachers of veterinary pharmacology in Britain are only now beginning to turn to the problem of producing a text-book in their subject to which the student or practitioner can refer. In this situation the Codex is particularly valuable.

P. JEWELL

Brompton Hospital Reports

Vol. 27, 1958. (A collection of Papers by Members of the Staffs of the Hospitals for Diseases of the Chest (Brompton Hospital and London Chest Hospital); and of the Institute of Diseases of the Chest.) Pp. x+277. (London: Lloyd-Luke (Medical Books), Ltd., 1959.) 15*s*. net.

FOR those who wish to follow the progress of knowledge of diseases of the chest this volume collects, in the handy and attractive form well known to readers of the earlier volumes in this series, twenty-one papers, all of which have been previously published in the journals named in the preface.

The volume opens with an appreciation of the fine work of Maurice Myers, who joined the staff of the Brompton Hospital Sanatorium in 1932 and spent the rest of his professional life there, being deputy medical superintendent for the greater part of this time. For him, as this memoir of his life says, the treatment of pulmonary tuberculosis was an art, and his death in December 1958 deprived us of the services of a man of long and wide experience.

It is impossible, in a brief notice, to discuss in detail the contents of the papers here reproduced. Three of them deal with the treatment of pulmonary tuberculosis by extraperiosteal plombage, thoracoplasty and streptomycin, isoniazid and sodium *p*-aminosalicylate. Two papers report respectively on the treatment of pleural effusions by antibacterial therapy and on the proteins in serum and the pleural fluid, while two discuss studies of tuberculin sensitivity in tissue cultures and in the middle-aged and the elderly. There are five papers on heart conditions, one on multiple brochostenoses due to sarcoidosis, one on pleural neoplasms and one on the surgery of œsophageal lesions. The volume concludes with four papers on bronchiectasis, bronchodilator drugs and bronchograms, and two on pulmonary mycoses in Britain and the occurrence of *Aspergillus fumigatus*. The list of papers published by the staff during August 1957–July 1958, and the author and subject indexes to volumes 1–27, summarize the great work that this hospital has been doing.

G. LAPAGE

Genetyka

By Edmund Malinowski. Pp. 582+14 plates. (Warszawa: Państwowe Wydawnictwo Naukowe, 1958.) Cena zl. 42.

THIS text-book on genetics by one of Poland's leading authorities on the subject follows the familiar lines of such books published in Western Europe in pre-war times. The reader is introduced to the principles of evolution through references to Darwin; the story of Mendel's discovery, and the rediscovery of Mendel, is retold and the now classical studies of the early Mendelians are described. The role of the chromosomes in heredity and in evolution is explained, and brief references are made to some of the more recent genetical studies such as those on biochemical mutants in micro-organisms and the Watson–Crick views on the structure of deoxyribonucleic acid.

The chapter on evolution contains a brief section on Lamarck and the inheritance of acquired characters; experiments of MacDougall, Harrison and others are shown to be susceptible of explanation as selection effects and the cautious conclusion is reached that there is no evidence so far that can be accepted as definite proof of the inheritance of acquired characters. There is no mention of the work of T. D. Lysenko and his school.

In the final chapter on the application of genetics in agriculture we are told that the main achievements in breeding improved wheat varieties for Polish conditions have been based on some original crosses between the English wheat Squarehead and the Polish Puławka. Mention is made of the production of hybrid maize and hybrid onions in the United States and of the artificial production of polyploid races of various crop plants in Sweden and elsewhere. In this connexion we are told of some tetraploids of serradella (*Ornithopus sativus*), produced by Polish workers, which exceed the original diploid strains in fodder yield by as much as 100 per cent.

P. S. HUDSON

EXISTENCE OF NET ELECTRIC CHARGES ON STARS

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I

IT has been found possible to account for the known orders of magnitude of five different astronomical phenomena and the directions relating to three of them by means of the single hypothesis that a star like the Sun of mass M_s gm. carries a net negative charge, $-Q_s$, which is given by the formula :

$$Q_s = \beta_s G^{\frac{1}{2}} M_s \text{ e.s.u.} \quad (1)$$

where G is the constant of gravitation and β_s is a pure number of the order of 0·03.

Thus, for the Sun we have :

$$Q_s = 1{\cdot}5 \times 10^{28} \text{ e.s.u.} \quad (2)$$

The same hypothesis leads to simple qualitative or semi-quantitative explanations of at least the thirteen other phenomena considered later.

The first five phenomena are as follow : (1) the magnetization of the Earth ; (2) the outer Van Allen belt of radiation ; (3) the maximum energy of about 5×10^{18} eV. found for a primary cosmic ray particle ; (4) the Sun's north polar magnetic field vector H_p ; (5) the approximate equality of the ratio P/U for the Sun to the mean value of this ratio for Blackett's[1] group of five magnetic stars, where P is the magnetic moment and U is the angular momentum of a star.

The phenomena 1–4 arise as follows from the presence of the solar charge $-1{\cdot}5 \times 10^{28}$.

The velocity of translation of the Sun relative to the Earth is $v_s = -29{\cdot}8$ km./sec. and consequently its charge, $-Q_s$, sets up in a non-rotating frame of reference accompanying the Earth a magnetic field H_r which is perpendicular to the ecliptic, directed from north to south and has near the Earth the intensity $6{\cdot}9 \times 10^{-9}$ gauss.

The magnitude and direction of H_r are approximately those required by J. S. Chatterjee[2] for the initial field, of unknown source, which saturates the highly permeable magnetic material of a 20-km. shell near the top of the Earth's crust and thus imparts to the Earth its observed magnetization. For Chatterjee requires a "field of the order of 0·1 to 0·01 gauss".

Moreover, the field H_r not only magnetizes the Earth but also neutralizes the resulting external terrestrial field in a narrow and approximately toroidal region which lies nearly in the Earth's equatorial plane and has a radius equal to about 3·7 earth radii. The magnetic field in and near this region is such that it could act as a 'magnetic bottle' which is partly accessible to energetic charged particles from much further out. These results account very well for the existence of the outer Van Allen belt which has a maximum density at about 3·6 Earth radii.

The Sun's charge also produces an electric field which has the potential $V = -3{\cdot}0 \times 10^{17}$ volts at the Earth's orbit. This field causes free protons and other nuclei in distant space to approach the Sun and move in orbits round it. Those nuclei which lose little energy on the way to the Earth's orbit will then reach this orbit with an energy of $3{\cdot}0 \times 10^{17}Z$ eV., where Ze is the charge on the nuclei concerned. For an iron nucleus this energy amounts to 8×10^{18} eV. Also the orbits of all the nuclei will be oriented at random. These results account very well for the observed maximum energy 5×10^{18} eV. of a primary cosmic ray particle and for the isotropy of cosmic rays.

The rotation of the negatively charged Sun imparts to it a magnetic moment which is directed from north to south. This in turn produces a north polar magnetic field vector H_p which would have the magnitude $-0{\cdot}75$ gauss if the Sun's charge were distributed in the same way as the mass and if the mass and angular velocity were distributed as in Chapman's[3] model A. A uniform distribution of Q_s throughout the Sun would yield the value $-8{\cdot}5$ gauss. These results agree in order of magnitude and direction with the observations of Hale and Langer who, according to a report by H. W. Babcock[4], found a mean value of -4 gauss. They also agree with the most recent observations of H. D. Babcock[5]. The presumably temporary reversal of the direction of H_p, during six years, which was observed by the Babcocks suggests that our estimated value of H_p corresponds to the constant component of the Sun's magnetic field, and that there exist also an oscillating component which varies with the solar cycle and a component due to local turbulence.

The fact (5) would arise from the hypothetical stellar charges specified by formula (1) if the Sun and the average of Blackett's five stars had axially symmetrical distributions of the angular velocity ω, the charge density σ and the mass density ρ such that at a point (r, θ) the quantities $\omega\sigma$ and $\omega\rho$ are each functions of θ and r/a alone, where a is the diameter of the star. The latter assumption is the reasonable one that magnetic stars are homologous rotating bodies.

It would be a remarkable coincidence if these five phenomena were all explained correctly in their orders of magnitude and their related directions by means of a single hypothesis which is entirely false, even if the last phenomenon calls for a supplementary assumption of homology in magnetic stars.

For, even if we make the moderate assumption that the probability of a false theoretical value A, of a physical quantity, agreeing in order of magnitude with the observed value B is less than 0·1, the probability of five such agreements and of three chance agreements of direction would be less than $1/10^4 \times 2^3$, that is, less than 1 in 80,000.

If to these eight agreements we add the thirteen other different phenomena which are qualitatively or semi-quantitatively explained below by means of the same 'false' hypothesis, the resulting coincidence would be truly extraordinary.

My hypothesis implies the existence of strong electric fields (but less than 10^9 V./cm.) in the Sun's atmosphere. In combination with the magnetic fields which exist there they could lead to relativistic electrons trapped in the corona. Three consequences of this situation are : (*a*) the phenomena cited by Kellogg and Ney[6] in support of their new theory of the corona ; (*b*) the high temperatures in the corona : (*c*) the acceleration and ejection of fast magnetized

and negatively charged clouds of ionized hydrogen, of the same general character as Bostick's plasmoids and rings, which are generated along with flares near strongly magnetized regions like sunspot groups.

These fast clouds could serve to explain the solar radio phenomena associated with flares observed by Wild *et al.*[7] and interpreted by them and by McLean[8] as indicating the early ejection of a fast stream of electrons with a mean velocity of about $\frac{1}{2}\,c$, and the subsequent ejection of a cloud of relativistic electrons at velocities of about 1,000 km./sec., that is, $c/300$. They estimate that the fast stream contains not less than 3×10^{32} electrons.

If we assumed that this stream diverges less than π steradians it would follow that at least 7×10^{35} electrons are intercepted by a sphere around the Earth of radius equal to that of the outer Van Allen belt. Consequently the intercepted electrons would tend to become trapped in the Van Allen belt and so to lower the Earth's potential by more than $4{\cdot}5 \times 10^9$ V. This would lead to a large transient increase in the intensity of the cosmic rays and also allow the entry into the Earth's upper atmosphere of a large flux of low-energy nuclei. The latter flux could be held responsible for the remarkable early and sudden increase of the electron density below 90 km. in the dark ionosphere following the great solar event of February 23, 1956; a similar flux has been suggested by D. K. Bailey[9], but his flux is assigned to a different origin. Both the transient increase of cosmic rays and the sudden increase of lower ionospheric ionization could occur within 10–30 min. after the strong solar flare commenced, as was observed to be the case. When the fast electrons stop arriving, the Earth's potential would commence to rise, by admission of nuclei, until it and the cosmic-ray intensity return to their normal values. The arrival of the slow magnetic clouds, after the lapse of 1–3 days, could then give rise to other effects, including magnetic storms and temporary decreases of cosmic ray intensity.

The value 0·03 for β_g is consistent with the fact that current theories of stellar constitution are good approximations for the Sun and (presumably) for Blackett's average of five stars. For even if we adopt Chapman's model A with $\beta_g^2 = 9 \times 10^{-4}$ the forces of electrostatic repulsion are only about one-thousandth of the corresponding forces of gravitational attraction.

If a star possessed a charge such that β_g approached or exceeded the value 1 and this charge became located mainly near the surface of the star, the forces of electrostatic repulsion alone would make its outer parts unstable and so lead to their expulsion. This suggests one possible explanation of novæ and supernovæ. A necessary accompaniment of such an explosion of a rotating star is the ejection of magnetized clouds and relativistic electrons; this alone would explain the existence of the mysterious spectra of certain novæ and also the polarized light and strong radio noise emitted by the Crab Nebula.

The emission of strong radio noise from large regions around some galaxies, such as the Galactic Halo, may be explained by regarding each of these regions as the atmosphere of the negatively charged and rotationally magnetized galaxy concerned. For such an atmosphere would necessarily contain trapped electrons with relativistic energies.

Lastly, we may expect that when two such charged and magnetized galaxies enter into collision they would set up strong electromagnetic disturbances in each other's atmospheres and so generate the intense radio noise which has been observed in such collisions.

A discussion of possible sources of the stellar net charges, some possible difficulties which may be raised by my hypothesis and some possible tests of it will be given in Part 2.

2

Possible sources of the stellar charge $-Q_g$, certain criticisms which may be raised against these hypotheses and possible tests of them will now be discussed.

A possible source of $-Q_g$ is provided by one of the following alternative hypotheses H_1 and H_2.

H_1: The thermonuclear processes in the interior of a star like the Sun generate certain particles, provisionally named 'astrons', each possessing a small mass m_a and a positive electric charge e_a many times smaller than the electronic charge e and able to penetrate matter as easily as a neutrino can. Under this hypothesis the star acquires a negative charge $-Q_g$ which is ultimately limited by the flow of nuclei into the star and the flow of electrons out of it.

H_2: As suggested in an earlier publication[10], the four-dimensional space-time universe U_4 is a hyper-surface in a five-dimensional universe U_5 and the laws of conservation of energy, momentum and electric charge hold true exactly in U_5 and only approximately in U_4. Consequently, there can exist streams of electrically charged particles from U_5 into U_4 or vice versa. Also the geometrical character of this hypothesis requires that these streams depend on the local metric of U_5, that is, on the local physical conditions in U_4; thus the streams inside a star would be different from those outside it. The streams from or into U_5 could then give a net negative charge to the star; they could also maintain this charge constant under any possible drains due to the emission of electrons into space and the attraction of nuclei from space.

This hypothesis H_2 may appeal more to theoretical physicists, for it can also serve to unify the theories of the gravitational, electromagnetic and quantum fields and one theory of cosmology[10]. The present application of H_2 to the interior of a star suggests that a correct theory of nuclear forces would be one that could be unified with the other four theories in a five-dimensional mathematical form. This suggestion receives some support from Rayski's[11] recent publication entitled "A Six-dimensional Interpretation of Electrodynamics and Nuclear Interactions".

The first hypothesis H_1 is more easily linked with current views about the thermonuclear processes inside stars like the Sun. For this can be done simply by adopting two supplementary hypotheses, namely (h_1) that astrons are neutrinos and (h_2) that a proton carries the same charge e as a positron and an electron carries the charge $-e$. From these hypotheses and the two known nuclear processes:

$$n^0 \rightarrow p^+ + \beta^- + \bar{\nu} \text{ (antineutrino)}$$
$$p^+ \rightarrow n^0 + \beta^+ + \nu \text{ (neutrino)}$$

it can be deduced that a neutrino carries the small positive charge e_a, and a neutron and an antineutrino each carries the negative charge $-e_a$. These hypotheses and deductions are also consistent with the current assumption that the principal thermonuclear process in the Sun is the proton-proton chain reaction in which two β^+ particles and two neutrinos (ν) are released for every four protons involved. Moreover, they are consistent with the remarkable fact that the neutron behaves like a spinning negative charge.

By means of certain arguments based on current views about the flux of neutrinos out of the Sun, 5×10^{39} per sec., and the mean energy of each, 0·25 MeV., it may be inferred that a necessary condition for most of the neutrinos to escape from the charged Sun is that $e_a \ll 4 \times 10^{-15}e$. Also an argument suggested by Dr. M. J. Buckingham, based on the same value of the neutrino flux, 5×10^{39}, and on the age of the Sun, 5×10^9 years, leads to the conclusion that $e_a > 4 \times 10^{-19}e$. It is remarkable that the net positive charge $e_h = 2 \times 10^{-18}e$ assumed by Lyttleton and Bondi[12] to be carried by a hydrogen atom lies between these limits to the value of e_a and is only five times as large as the lower (and nearer) limit. This fact and their use of the charge e_h to explain galactic recession suggest that some elaboration of my hypothesis of negative stellar charges could also serve to explain this recession. For example, the additional assumption that the Population II stars in the galaxy have charges Q_s such that $\beta_s > \cdot 1$ and are so related in number to the Population I stars that the average value of β_s for the galaxy is about 2·2 could allow the forces of mutual repulsion between my negatively charged galaxies to set up the same velocities of recession as those set up by the excess positive charge in the universe of Lyttleton and Bondi.

The hypothesis H_1 may possibly form part of the hypothesis H_2 when the latter has been developed mathematically and otherwise.

It may be argued that the main hypothesis is untenable because: (*a*) interstellar space appears to be too highly conducting and (*b*) the negatively charged star would quickly lose its charge by the emission of free electrons. This argument is nullified by the hypothesis H_2 under which there exist streams of charged particles from or into U_5 which can replace any lost negative charge by an equal amount of fresh charge. But even under the hypothesis H_1 this argument has little force until, (*a*) it can take full account of the evidence that now exists that interstellar space contains coherent magnetic clouds of ionized hydrogen and that in the Solar system such clouds are continually flowing away from the Sun (see Parker[13]), and (*b*) it can be proved that a highly magnetized sphere of hot condensed hydrogen like the Sun cannot under any conceivable distribution of its negative charge $-Q_s$ retain for long the charge which is left by the emission of my positively charged neutrinos.

Another possible criticism is that my theory does not account for the existence of an extended spectrum of cosmic ray energies. This criticism is met by pointing out that not only do the attracted nuclei start from points at different distances from the Sun but also different nuclei encounter different obstacles on their way to the Earth's orbit, such as the magnetic clouds mentioned above, and so lose different amounts of energy through these encounters. The latter process would become more effective if, as is probable, most of these magnetic clouds were negatively charged by electrons trapped in their fields.

A fourth objection which may be raised against the theory is that during some six years the general magnetic field of the Sun was opposite to that set up by the negative charge $-Q_s$. This is met by Blackett's suggestion that a slow electromagnetic oscillation may be superimposed on the unidirectional general field and by the possibility that the observed effects of the latter may sometimes be obscured by those due to the irregular fields arising from turbulence.

Another possible criticism is that the theory is contradicted by the apparent transient generation of low-energy cosmic-ray particles in the Sun following certain flares. This criticism is met by referring to the discussion in Part 1, in which it is shown how the very fast solar stream of electrons, inferred from the radio observations of Wild *et al.* at times of strong solar flares, can transiently lower the electric potential of the Earth and so transiently increase the intensity of the flow of low-energy primary cosmic-ray particles into the Earth's atmosphere.

Lastly, it may be argued that the electric fields in the Sun's atmosphere set up by its charge should be revealed by the presence of large Stark effects in some of the spectral lines. This argument is not conclusive, because the Stark effects which have been observed are usually attributed to atomic electric fields which can be greater than the solar fields, and also because about 43 per cent of the lines in the spectrum of the Sun are as yet unidentified and may therefore arise in part from large Stark effects.

A more complete account of this work is in the course of publication in the *Journal and Proceedings of the Royal Society of New South Wales*. In that account three possible experiments are described, and two predictions are made which may serve to test the theory or parts of it.

One of these experiments is to determine, by means of satellite-borne magnetometers, the Earth's equatorial magnetic field and its direction at distances up to at least ten Earth radii. Another experiment is to determine whether Bostick's plasmoids (or rings) carry net negative charges by firing them into or through Faraday cages.

One of the predictions is that, during the next ten years, the value of the Sun's north polar magnetic field will return to the mean value and direction, − 4 gauss, which were found by Hale and Langer.

I wish to acknowledge the valuable help which has been given to this work by the expert advice and criticisms of numerous colleagues and friends, in particular those of Profs. S. T. Butler, H. Messel and C. N. Watson-Munro, and Drs. M. J. Buckingham, R. G. Giovanelli, R. E. B. Makinson, H. D. Rathgeber and J. L. Pawsey, and Messrs. A. F. A. Harper, J. P. Wild and H. Wood.

Note added in proof. If the formula (1) is also applied to the planet Jupiter, which resembles the Sun in its chemical constitution and in emitting strong, elliptically polarized radio noise, the polar magnetic field resulting from a uniform distribution of Q_s and from the planet's rotation has an intensity of about 5 gauss. This approximates to the value 7 gauss derived by A. G. Smith and T. D. Carr (*Astrophys. J.*, **130**, 641 (1959)) from observations of Jupiter's radio noise.

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PADDY SOILS AND RICE PRODUCTION

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DURING 1954, an annotated bibliography[1] of rice soils and fertilizers was compiled by G. V. Jacks and M. Kathleen Milne. This has more than 900 entries, but does not include some valuable papers on paddy soils in Japan that were presented at the fourth session of the International Rice Commission, held in Tokyo during 1954. Much of the following summary is based on three of these papers: a historical review[2] by Harada *et al.*; a study of the chemistry of paddy soils[3] by Shioiri and Tanada; and a study of soils and fertilizer use[4] by Mitsui.

Paddy fields of Japan are mostly located on well-drained alluvial soils of Recent origin. Their subsoil remains continuously oxidized to a considerable depth: below this there may be a gley horizon due to a permanent water-table. Irrigation during the summer sets up reducing conditions in the topsoil which becomes bluish grey to a depth of 25 cm. or so. When the crop ripens the fields are allowed to dry and the whole furrow slice becomes oxidized. When irrigation is resumed in the spring vigorous growth of algae and duckweed occurs. These take up carbon dioxide during the day, allowing the surface water to become alkaline by the afternoon, and give off carbon dioxide at night so that the surface water is weakly acid by the early morning. Oxygen produced during the day and diffusing atmospheric oxygen reach the soil surface, which remains brown to a depth of a few millimetres. Below this a very thin (0·5 mm.) layer of hydrated ferric oxide may sometimes be found. This is an embryonic upper iron pan formed by oxidation of ferrous compounds diffusing upwards from the bluish grey reduced layer. The diffusion of iron seems to be accompanied by localized and perhaps progressive bleaching of the bluish grey layer. In this layer reduction of nitrate, sulphate and ferric ions takes place and a consequent lessening of acidity. A lower more substantial pan containing iron and manganese oxides may be formed by downward diffusion at the junction of the reduced layer and the oxidized subsoil. Similar iron pans have been observed in north-west England by Crompton[5]. If concentrated nitrogenous fertilizers are applied at the surface, nitrate formed in the surface layer is leached downwards; denitrification occurs in the reduced layer and is accompanied by loss of gaseous nitrogen or nitrous oxide, this loss being more serious than that due to deep percolation. The soil of an irrigated field can be represented as in Fig. 1.

Yields are increased by 10 per cent or more if paddy fields can be dried off between successive crops. When air-dried paddy soil is flooded, anaerobic micro-organisms regain the ascendancy and ammonium nitrogen is produced in greater amount than from continuously wet soil. The increase, amounting perhaps to 20 kgm. nitrogen per hectare, is readily taken up by the rice plant. Air-drying prior to flooding also increases the availability of phosphate. Aoki[6] concluded that the effective part of the phosphoric acid in paddy soils appears to be present as iron compounds, their solubility being increased by conditions of reduction. Similar conclusions are drawn by Paul and De Long[7], Islam and Elahi[8] and by Gasser and Bloomfield[9], who found that phosphate associated with iron is mobilized by anaerobically fermenting organic material. Ponneramperuna *et al.*[10] consider that the rice plant benefits from the increased availability of iron but may suffer from an excess of reduced substances.

Ammonium sulphate should be worked into the soil before the first flooding or, surprisingly, it can be mixed with peat or peaty soil to form egg-size balls which can be thrust into the flooded soil. This latter method is specially recommended for 'degraded' paddy soils in which damage from hydrogen sulphide is feared. It has recently been stated[11] that urea is preferred to ammonium sulphate as nitrogenous fertilizer for 'degraded' paddy soils as well as for acid soils of Japan. In lowland paddy soil the sulphate of chemical fertilizers is readily reduced to sulphide which, if soluble, inhibits respiration of plant roots and so prevents selective uptake of potassium and uptake of phosphate and other plant nutrients. This physiological disorder involving root-rot is known in Japan as *akiochi* or 'fall-down'. According to the observations of Sethi[12], Crafts and Broyer[13], van Raalte[14], Vlamis and Davis[15], rice thrives in waterlogged soil because its young roots supply oxygen to the otherwise reduced soil: if iron is present in solution, the young roots acquire a yellowish brown coating of ferric hydroxide gel which apparently protects the roots against moderate amounts of hydrogen sulphide. The oxidative action of the roots ceases or grows less at flowering, this decline possibly being associated with differential response to potash of young and older rice plants noted by de Geus[16].

The 'degraded' soils which occupy about 17 per cent of the lowland rice area of Japan are described as follows: (1) the furrow slice is grey and shows little evidence of 'active' iron (as estimated by Truog's method using sodium sulphide and oxalic acid); (2) the plough sole layer is usually bleached; (3) below the plough sole there is a layer where ferric and occasionally manganic oxides accumulate; (4) in mid-summer the furrow slice emits hydrogen sulphide

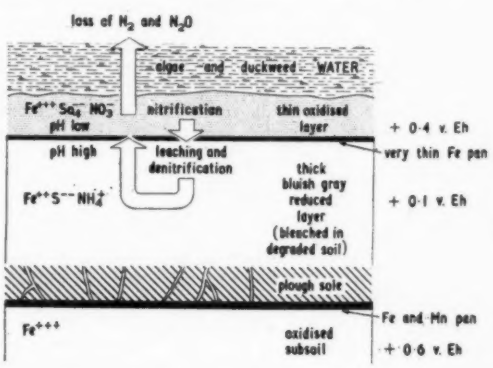

Fig. 1

gas; (5) roots of rice are whitish and lack the coating of ferric oxides which would protect them from damage by hydrogen sulphide. This description corresponds closely to that given by Koenigs[17] for a 'sawah' profile in Java: de Gee[18] has determined the oxidation potential of the 'sawah' profile. His results are shown in Fig. 1. According to Mitsui[4], the 'degraded' paddy soil occurs on siliceous materials such as are derived from acid igneous rocks or sandstone. It may be supposed that these materials occur mainly as low-lying alluvial deposits, that they contained little iron at the time of deposition and were readily leached.

Observations of Bloomfield[19,20] suggest that leaching and precipitation of iron oxide in poorly drained soils commonly involve formation of soluble complexes of ferrous iron by the action of decomposing plant remains. The complexes are sufficiently stable to be transported by percolating water, but if brought into contact with ferric oxide they are sorbed and the ferrous iron is readily re-oxidized. Following up these ideas, Jeffery[21] has added excess water to oxidized soil plus organic matter and has observed: (*A*) a rapid fall in redox potential, which is followed by (*B*) a fairly rapid recovery; and by (*C*) a slow decline such as is given by soil plus water in the absence of added organic matter. He ascribes stage *B* to oxidation by ferric oxide originally present in the soil. This recovery leads to a desirable situation *C* in which both ferric and ferrous ions are present. For stage *C* Jeffery derives an equation relating *Eh* and *p*H. The observations lead to a more precise understanding of the balance of oxidation-reduction at different seasons and at different parts of the soil profile. In a second paper[22], Jeffery develops an equation in an attempt to define optimum conditions for rice growth and thus the suitability of any given soil for paddy. Shioiri and Tanada[3] found in a laboratory test a marked fall in redox potential on adding excess water to samples from the furrow slice of paddy soil, whereas samples of upland soil showed little change. Paddy soil that had been treated with organic fertilizer produced abundant hydrogen sulphide when water-logged, whereas corresponding upland soil did not. The upland soil presumably had a greater reserve of ferric oxide. Accordingly, heavy applications of upland soil are used with some success to improve degraded paddy soils.

These studies, arising from the pioneering work of Prof. W. H. Pearsall (see review of Grist's book on p. 507 of this issue), are of more than academic interest: they should contribute to increased production of this crop, which is vitally important to so many millions of patient, hard-working people. Much is already being done. In Japan, soil survey (Endo[2]) has been directed to mapping different kinds of low-yielding land, including *akiochi* (degraded) paddy fields, acid soil, low-yielding volcanic soil, saline soil, poorly drained soil. Improvement is then sought by appropriate means, for example, by adding iron-rich materials to degraded soils and by appropriate use of fertilizers as described above; by addition of calcareous materials to acid soils; by improvement of drainage. D. H. Grist[23] rightly considers that improved water control is the best way of raising rice yields. The following may be included among the encouraging results obtained by use of fertilizers. Richardson[24], describing 81 field experiments on paddy fields in China, recorded the following responses to 60 kgm. per hectare applications reckoned as nitrogen, phosphate and potash: mean yield, 2,805 kgm. per hectare; responses—nitrogen, +620; phosphate, +290; potash, +40 kgm. per hectare rough rice, that is, threshed grain. On the advice of Stewart[25], very numerous experiments with fertilizers have been carried out on farmers' fields in India. Yates, Finney and Panse[26] recorded, for 2,445 experiments in Bihar, India, a profitable response of 280 lb. threshed grain/acre to 20 lb. nitrogen per acre; phosphate was profitable only on responsive soils. Numerous additional experiments during the period 1953–56 indicate[27] that a dressing of 20 lb. nitrogen/acre plus 20 lb. phosphate per acre would generally be the most profitable for paddy in India. In the north and north-east, the dressing of nitrogen can be increased to 40 lb. with or without application of phosphate; in certain areas distant from the coast, the dressing of phosphate can be raised to 30 or 35 lb. phosphate per acre. Potash at 20 lb./acre gave a profitable return in some areas, including two centres in Bihar. Ashby[28] found from 173 completed experiments on farmers' wet paddy fields in Kelantan, Federation of Malaya, an economic response to 200 lb./acre of placed fertilizer supplying nitrogen, 23·5; phosphate, 20; potash, 25 lb./acre. In Zanzibar, Tidbury[29] found the most profitable dressing to be 2 cwt./acre ammonium sulphate plus 3 cwt./acre of superphosphate. It is worth mentioning these results that derive only in part from a more accurate appreciation of wet soils. The possibilities are more encouraging than might appear from the earlier investigations. Important observations on response to phosphate applied to wet paddy fields of British Guiana were made by Gasser[30]. Factorial experiments carried out on three kinds of soil gave results as shown in Table 1, while analysis of straw and threshed grain from these experiments gave percentage contents of phosphate shown in Table 2.

Table 1

Site	Soil	Threshed grain (lb./acre) With phosphate	Threshed grain (lb./acre) Without phosphate
Cane Grove	toxic aluminium pegassy clay	2,977	409
Mahaicony Abary	fertile frontland clay	2,740	1,769
Botanic Gardens		4,126	4,102

Table 2

Site	Straw With phosphate	Straw Without phosphate	Threshed grain With phosphate	Threshed grain Without phosphate
Cane Grove	0·036	0·036	0·159	0·117
Mahaicony Abary	0·049	0·038	0·244	0·160
Botanic Gardens	0·107	0·105	0·293	0·299

In comparison with the other low-lying soils, the higher fertility of the frontland clay (derived from marine alluvium) in the Botanic Gardens, British Guiana, is clearly shown in the satisfactory phosphate content of grain from plants which had not received phosphatic fertilizer. The soils increase in acidity and in content of exchangeable aluminium in the order: Botanic Gardens < Mahaicony Abary ≪ Cane Grove. The Cane Grove soil, considered to be formed by sedimentation in brackish water, is like the gyttja soils studied by Wiklander and co-workers[31–33] in Sweden, and is related also to soils of mangrove swamps studied by Tomlinson[34,35] and by Hart[36] in Sierra Leone and to the 'gelam' soils of Malaya (Coulter, ref. 37). Such soils occur widely and I have suggested[38] that sulphur, readily leached from humid uplands in the form of sulphate, may be

arrested in reduced form in lowland deposits together with elements forming insoluble sulphides. When air gains access to such deposits (for example, when water-levels fall because rain has been less heavy than usual) oxidation rapidly occurs, with formation of sulphuric acid in sufficiently high concentration to react with clay to form aluminium sulphate.

Of course, much has yet to be learned about these poorly drained or water-logged soils, which differ so sharply from upland soils that ordinary methods of analysis may be misleading or fail to yield significant results. At present it seems permissible to distinguish, as three corners of a triangular diagram, well-drained paddy soils, which are fertile; *akiochi* or degraded paddy soils which are infertile for lack of iron; paddy soils related to gyttja which are infertile owing to excess of aluminium. The preceding brief account refers to mainly mineral soils: some corresponding features are shown by peaty soils, for example, the pegassy soils of British Guiana seem related to gyttja. This subject will be more conveniently discussed on some later occasion. Current work (Bloomfield, C., private communication) indicates that decomposing plant remains mobilize not only iron but also many other elements of importance in plant nutrition.

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THE CENTO INSTITUTE OF NUCLEAR SCIENCE IN TEHRAN

By H. A. C. McKAY

Director

TO meet the great world-wide interest in nuclear science and its applications, it has often been suggested that regional centres should be created. Each centre would provide training and research facilities for a group of neighbouring countries. The first of such centres to be established is the CENTO (Central Treaty Organization) Institute of Nuclear Science, formerly the Baghdad Pact Nuclear Centre, which now serves the three countries of the CENTO region, Iran, Pakistan and Turkey. The Institute is concerned exclusively with the peaceful uses of nuclear science, and forms one of the quite extensive economic activities of the Central Treaty Organization.

The original Nuclear Centre in Baghdad was formally opened on March 31, 1957 (see *Nature*, 179, 936; 1957) and trained about sixty Middle East scientists in nuclear techniques, before the Iraqi revolution brought operations to a close. A decision to re-establish the Centre in Tehran was taken jointly by the CENTO countries in January 1959, and on June 23, 1959, H.I.M. the Shahenshah of Iran performed the opening ceremony in the presence of a distinguished audience. Two training courses have since been held in Tehran. The re-naming of the Baghdad Pact necessitated the re-naming of the Centre, and the present name was adopted in November 1959.

All the CENTO countries contribute to the running of the Institute. Its scientific policy is in the hands of a Scientific Council consisting of a leading scientist from each of the four countries; the United States sends an observer. The Scientific Council reports to the Economic Committee of CENTO, and in general administrative matters the Director of the Institute maintains liaison with the Deputy Secretary General for Economic Affairs of CENTO. The British representative on the Scientific Council is Sir John Cockcroft, and the Institute owes him a great debt for his continued efforts on its behalf.

Finance and staff are provided by all the CENTO countries. Iran has provided accommodation in the new and modern Faculty of Science building in the University of Tehran. The United Kingdom has provided the initial stock of equipment, worth about £20,000, most of which was flown out by charter plane.

The link between the Institute and scientific establishments in the United Kingdom is vital to its operation. Much of the value of the Institute is due to its serving as a channel for British knowledge and experience in the nuclear field to reach the CENTO

region. The United Kingdom Atomic Energy Authority has provided the Director and five other scientists out of the Institute's total complement of twelve scientific staff. The British staff have been carefully chosen so that between them they cover the basic fields of nuclear physics, electronics, radiochemistry and health physics; the number could not be cut without affecting vital services. The present Director is a radiochemist from the Atomic Energy Research Establishment at Harwell, and his predecessor, W. J. Whitehouse, was a nuclear physicist from the same Establishment. The personal connexions with Harwell are such that advice and help are readily obtained from that source.

While the British staff cover the fundamental physical and chemical aspects of nuclear science, staff from the region are often specialists in one or other of the biological sciences. They are thus able to co-operate with the British staff in the development of applications of interest to the region, especially in agriculture. Attached to the Institute there is also a CENTO Senior Research Fellow, Dr. C. J. Banks, an entomologist from Rothamsted Experimental Station, who is applying radioisotopes in his particular field. The region staff have in many cases had a period of training in the United Kingdom before joining the Institute.

At present the Institute is engaged primarily in work with radioisotopes, which offers the best starting-point for the region in nuclear science. Its main activities fall under two heads: training courses and research projects.

The first training course in Tehran lasted nearly two months, from mid-September to mid-November 1959. It was attended by thirteen students from Iran, Pakistan and Turkey, all having at least a university science degree, and two being professors at their own institutions. (The Institute actually has space and equipment for twenty students working in pairs.) The course was comparable with those given at Harwell, Oak Ridge in the United States and elsewhere, though perhaps rather fuller, and taking rather less for granted as regards familiarity with modern laboratory techniques.

Ten of the students are staying on at the Institute for the rest of the academic year for advanced training or research, largely in fields of their own or their home institution's choosing. It is something of an experiment to operate in this way. A criticism of the courses given earlier in Baghdad was that they were too short; in the time available, the students could not digest their new knowledge sufficiently to be able to use it immediately on their return home. (The same criticism would apply, perhaps even more strongly, to most radioisotope courses elsewhere.) Merely to extend the courses did not seem very satisfactory, because the essential ground was already covered. However, by keeping the students on project work for several months, it is hoped to provide a sufficient assimilation period in the right atmosphere. It is hoped, too, that the students will catch something of the research spirit from the experienced scientists at the Institute.

The projects now in progress include water-flow studies by radioactive labelling and tritium counting; testing of cement and of archæological specimens by beta-ray back-scattering; solvent extraction and ion exchange work in solution chemistry; synthesis of labelled carbon-14 compounds; observation of cytological changes in plants grown under the influence of phosphate labelled with phosphorus-32; and a study of the food reserves of certain insects. There is also quite a large project on the study of the migration of wheat pests (*Aelia* and *Eurygaster* species) by radioactive labelling of the insects. This was initiated by W. T. Spragg, chief chemist, at the Centre in Baghdad, and pilot-scale field-trials were carried out last spring in Anatolia and near Tehran, under CENTO auspices. A further trial is planned this year.

When the students return to their home establishments, the Institute intends to continue to follow the progress of their researches, and to send its staff on consultative visits. Being in the region, it can offer much closer support than could a training centre in Europe or the United States.

The second course at the Institute in Tehran was a special radioisotope course for agriculturists, running from mid-January to mid-March. Eleven students from the region attended, of the same general calibre as those on the first course. The course contained less nuclear physics and radiochemistry than the first (general) course, and concluded with a series of lectures and experiments dealing specifically with biological topics.

Although the main emphasis at the Institute is on radioisotope work, with some bias towards agricultural applications, it is prepared to help in any field of nuclear science, in accordance with the needs of the CENTO region countries. The staff, between them, are of quite wide experience, and can moreover draw on the very large resources of Harwell. Assistance has already been given in testing uranium- and thorium-prospecting equipment, and some of the students are receiving preliminary training for reactor and gamma-irradiation work. Moreover, the Institute has been promised facilities on the 5-MW. swimming-pool reactor, on which construction work is just starting at the University of Tehran Nuclear Centre a few miles from the Institute. The University of Tehran also possesses a 3·5-MeV. Van de Graaff machine, a mass spectrometer, and a beta-ray spectrometer, which it is proposed to erect at its Nuclear Centre.

In the medical field, the Institute is giving all the encouragement it can to the establishment of a radioisotope clinic in Tehran. Until this exists, medical students at the Institute can get very little direct practical experience in their own particular field, although they can still obtain a great deal of benefit from the instruction given in general nuclear techniques. Most of the equipment necessary for such a clinic is already in Tehran, and there are medical men keen to use it, so it is to be hoped that work will start in the fairly near future. It may also be noted that the United Kingdom has recently presented a 1,000-curie radiocæsium therapy unit to the Faculty of Medicine of the University of Shiraz.

Certain lessons have been learned in setting up and operating the Institute, which may be of interest to those planning a similar venture. As regards equipment, it is important for the Institute to be well stocked with instruments of general use, such as ovens, thermostats, *p*H meters and incubators; it is usually too late to think of ordering such items for specific researches after the students arrive. A quick supply channel for chemicals, radioisotopes and other small items is vital, and Tehran's position on trunk air routes was a factor in the choice of location. Rapid clearance of radioisotopes through the Customs has been arranged with the Iranian

authorities. The Institute has found it necessary to instal its own electrical generator to ensure a constant supply, and steps are being taken in co-operation with the University of Tehran to put into operation a liquid-nitrogen plant.

As regards staff, the CENTO region countries have understandable difficulties in releasing good scientists to work at the Institute. Partly this is because trained scientists are in great demand in their home countries, and partly because of financial difficulties; the latter will, it is hoped, be surmounted. Technicians and junior laboratory staff are also hard to find, and there is a great need to train people for such jobs, as well as to overcome the social attitudes that tend to deflect people from them. The Institute offers training especially in electronics under D. R. Cockbaine, chief electronics engineer, and it is to be hoped that the CENTO countries will take full advantage of the opportunity; electronics servicing is an essential part of a nuclear science programme.

On the financial and administrative side, the Institute has a fair degree of autonomy within the broad lines of policy laid down for it. The finances are largely centralized in a single budget, from which all expenses are paid according to the Institute's own rules (which are based on those of the CENTO Secretariat); this avoids the complications of having to deal with the separate regulations of four different Governments.

Certain aspects of the Institute's work presuppose co-operation with a national atomic energy authority. Any operation involving possible release of radioactivity outside the Institute itself may come in this category. The Institute's insect-labelling project is the most important immediate example, and waste disposal is another which will arise in the future (for the present all radioactive waste is stored). Relations have therefore been established with the Atomic Energy Commissions of the three countries of the region.

The immediate success of the Institute encourages the hope that it will become established as a scientific centre of high reputation in the Middle East. Its character may change somewhat, as the atomic energy programmes of Iran, Pakistan and Turkey get under way, and they begin to conduct their own radioisotope courses. (For Iran and Turkey especially, these will have the advantage of being in their own languages.) The future trend at the Institute may then be towards more specialized training and towards research projects. The benefits should be felt in many fields, owing to the wide ramifications of nuclear science.

OBITUARIES

Prof. E. P. Stebbing

Prof. E. P. Stebbing, whose death at the age of ninety occurred on March 21, must have surpassed the now almost legendary Sir William Schlich, whose pupil he was, both in the number of years he presided over a forestry school, and in the number of forestry students who passed through his hands. His influence on forestry was far greater in the educational field than in any other, despite his special interest and numerous writings on forest entomology and soil erosion.

Interest in entomology showed early when he was still under training for the Indian Forest Service at the Royal Indian Engineering College at Coopers Hill. In 1900 he had the distinction of being the first forest officer in India to be appointed to a scientific research post, that of forest entomologist, having served in an executive capacity as assistant and deputy conservator during his first seven years. The post of forest entomologist had only been sanctioned for two years, and was not renewed; but it so happened that the post of superintendent of the Indian Museum at Calcutta was vacant, and Stebbing was given an officiating appointment. When the Forest Research Institute was established at Dehra Dun in 1906 he was the obvious man to deal with entomology, and he worked there as Imperial forest zoologist until his return to Britain in 1910.

During his time in India and Burma he did a remarkable amount of pioneer work, the results being published as *Forest Bulletins* (8) and *Leaflets* (5), and *Indian Forest Records* (3) and *Memoirs* (5), dealing with insects injurious to many of the chief timber species, namely, teak, *Shorea robusta*, *Acacia arabica* and the conifers, as well as with the lac insect. His best-known entomological work is his "Indian Forest Insects of Economic Importance: Coleoptera" (1914). Stebbing's biological work was of a higher standard than his contributions to taxonomy, which obviously did not interest him so much; but in those days he could scarcely have avoided it since so few of the insects with which he was concerned had been named and described.

In 1910 he was appointed lecturer in forestry in the University of Edinburgh, and nine years later became the first professor of forestry there. He had thus completed more than forty years when he retired in 1951 (*Nature*, **167**, 670; 1951).

Stebbing travelled widely, having visited Macedonia (as transport officer during the First World War) and the U.S.S.R., and afterwards many of the British and French Colonies, especially in West Africa. The country of his choice was patently France, and annually from 1921 he took groups of students there for part of their training. He had many friends in the Département des Eaux et Forêts, and just before he retired he was doubly honoured by having the Croix de Chevalier de la Légion d'Honneur conferred on him, and one of the famous ancient oaks in the Forêt de Tronçais named after him.

On the topic of erosion, Stebbing was strongly of the opinion that the administrators were inexcusably slow in taking—or enforcing when necessary—soil conservation measures, by preventing further denudation of vegetation, restricting excessive grazing, and undertaking constructive works. From his writing and speeches on this subject, he might have been considered somewhat of an alarmist, especially as to the rate of the 'advance of the desert' everywhere, though with special reference to the Sahara.

His most enduring publication will undoubtedly be his historical book on the "Forests of India" (1926). It is truly monumental in size, approaching 1,900 pages in three volumes covering the subject in great detail from its beginnings in the 1850's down to 1925. For the third volume covering the period 1900–25, he was able to use freely memoranda prepared for him by a large number of serving officers, but in doing so he drew on his own experience and added his personal views, thereby making the story much more alive

and interesting than it would otherwise have been. He re-visited India and Burma in connexion with this work and was engaged on the preparation of a further volume to bring the history up to 1940 at the time of his death—I recently took over from him the task of completing and publishing it (extending it to the end of the British regime in 1947).

As a teacher, Stebbing had very definite ideas of what was best for his students, and kept as firm a rein on the curriculum as he did on his horse. He always rejected any suggestion of loading up his undergraduate course with more basic science, considering that practical forestry had not yet advanced enough for it to be of any value: his course was accordingly more weighted on the technological side than elsewhere—which might not have been expected in view of his own early specialization. Possibly he was inclined to overstress the model of advanced European practice, rather curiously adding an overdose of engineering and surveying appropriate to India and Burma in the old days.

No account of Stebbing's life would be complete without reference to his personality. Small and spare, he was exceptionally 'tough' both on foot and as a horseman, and remained so until an unusually advanced age. Stories of his walking performances still persist in India, while his equestrian ride from his home in Kent (Romden Castle) to London in 1935 when he was sixty-five was no isolated feat.

During much of his time at Edinburgh, Stebbing had the largest number of students among the four university schools of forestry in the United Kingdom. Many of them had been sent from overseas, and these and many others are serving or have served in the forest services of Britain and all countries of the Commonwealth; in fact, cases could be quoted where the large majority of the officers of the Forest Department were his men. One can safely prophesy that his record will never be repeated, and he will long be remembered in all forestry circles.

H. G. Champion

Prof. E. J. Kraus

Dr. Ezra Jacob Kraus died at Corvallis, Oregon, on February 28 at the age of seventy-four. He was distinguished throughout the United States both for his massive contribution to scientific horticulture and for his flair for friendship with young botanists. He graduated from Michigan State University in 1907 and spent the first eleven years of his academic career in Oregon State College. In 1919 he went from Oregon to the University of Wisconsin; after a few years there he accepted an invitation to a chair in the botany department in the University of Chicago, where he stayed until his retirement in 1949.

The scientific work for which Kraus is remembered is his analysis of the balance of carbohydrate and nitrogen in plants in relation to fruiting. He demonstrated that many crop plants did not bear fruit unless a balance was maintained between these two classes of compounds. Some of his disciples greatly over-simplified his ideas by talking loosely about a carbohydrate–nitrogen ratio (or even a C/N ratio); but Kraus himself always realized that the relation between chemical composition and fruiting was a subtle and complex one, and he was impatient of these facile simplifications. Kraus's ability to diagnose why crops failed to bear fruit was quite astonishing. He showed (for example) how low yields in the apple orchards in the Hood River valley were due to over-manuring coupled with early pruning. A score of other examples could be cited, where fruit growers were able to improve their yields by controlling the balance of carbohydrate and nitrogen by means of simple horticultural practices: manuring, pruning, ringing and the like.

In Chicago he turned his attention to the anatomical effects of plant growth hormones, and (during the War, when he was attached to the U.S. Department of Agriculture) to the use of hormone-like chemicals for weed control; in both these fields he did important work.

But in the memories of hundreds of students Kraus will survive as a man rather than as a research worker. His influence on the graduate students who passed through his hands was enormous. It was conveyed through a quiet approach, a slightly cynical modesty, a bubbling sense of humour, and above all an impression that the priority which Kraus put first in his life was to spend time with young men, to talk to them, to travel with them, to pass on to them his enthusiasm for scientific horticulture. He was a capital 'debunker': indeed his interest in applied science and his suspicion of pure science sometimes led him to distrust research which seemed too sophisticated, and the succession of young men who had the privilege of his friendship remember with zest his mocking pragmatism.

Kraus disliked administration and committees, and he retired early (partly on account of illness) to spend the rest of his life doing the work he loved in the place he loved. From 1949 until his death, as a visiting professor of horticulture at Oregon State College, he devoted his time to horticulture, especially to the production of new varieties of chrysanthemums, and to cultivating his friends. He died after a long and painful succession of illnesses.

Kraus received wide recognition for his distinction in American botany. He was president of the Botanical Society of America in 1933 and of the American Society of Plant Physiologists in 1928, and he won many medals and prizes for his horticultural work. Much of his work is inevitably out of date: but his influence on a generation of botanists will endure.

E. Ashby

Sir Leonard Woolley

Charles Leonard Woolley, who died on February 20, nearly eighty years old, was perhaps the most internationally famous archæologist of his generation. This reputation was built upon far more than the fact that he best represented the ordinary man's notion of an archæologist, namely, a digger-up of the lore, but especially the treasures, of antiquity. Certainly this was his life's work, and certainly his successes in it were outstanding. He was constantly in the field (in Egypt, Syria, above all in Iraq), he never belonged to any institution, he never undertook to teach students (except by practical example to his assistants), and he scarcely attempted academic literature in his subject.

Yet even among those few who could have worked so widely and so hard as he, many would have fallen short for want of certain talents which Woolley possessed. First, by some scarcely explicable gift, he could find the most rewarding spot to work, whether it was the choice of Atshanah (the ancient

Alalakh) in 1937 among the multitude of settlement-mounds in its area, or the divining, season after season, at Ur of the most significant quarter to unearth in the great city. There he conducted, beginning from 1926, his most famous operation, revealing the royal tombs of Sumerian rulers who had held sway over the city in a period of unequalled splendour, about 2,500 B.C. as now believed, unhappily just before writing, already in use, had learned to record history.

In this great discovery also was best exercised the next in order of Woolley's talents, namely, a fine appreciation of materials in the ground, how they should each be reached, traced, or penetrated, how objects sighted should be protected from impacts of tools or of the atmosphere, how they should be lifted, and how first-aid should be given for their protection, transport, and even their ultimate reconditioning. Many almost deceptively 'well-preserved' exhibits in museums are now substantially as they left Woolley's hands, not restored or falsified, but skilfully extricated by him and remoulded to the shapes which they had lost by decay and pressure of earth. Much of his work of this kind was brilliantly improvised in days which, although not long past, were before the very recent development of preservation laboratories and techniques in museums.

Woolley had, moreover, a notable facility of exposition, which worked in two ways: an attractive lecturer and writer for general audiences, he was also —more important for one whose discoveries could well speak for themselves—a judicious author of excavation reports, that difficult marginal literature which, always bulky, is worthless if it strives for effect, repulsive and unreadable if too painfully 'scientific'. Woolley's many publications were highly successful in these two kinds; his popular works are both interesting and well founded upon his discoveries (whereas his few attempts at more general themes are not very valuable), and his large volumes of excavation reports have the virtues of well-arranged matter, ample pictures and plans, and careful description based upon his industrious recording in the field. Such descriptive parts can nearly always be read with interest and ready understanding. Some have, indeed, criticized his observation as not being of the exactitude demanded by the most recent methods, and it is true that Woolley could be intuitive in his perception of archæological levels and his mental reconstructions of buildings and fragments. But such criticisms seem not to make enough allowance for the character of most Near Eastern sites, and the pell-mell of dwellings and artefacts of different ages, often jumbled together, which they usually exhibit.

Woolley's lively mind and exploring intelligence, if they sometimes led him beyond his evidence, were of more service in suggesting many true and fruitful consequences of his discoveries. These, as great and varied as have fallen to any modern digger, are his principal bequest and his enduring memorial.

C. J. GADD

Dr. Eric Boehm

DR. ERIC BOEHM, who died suddenly at Cardiff on December 28, was a well-known and respected figure in industrial chemical and pharmaceutical circles. Born in Breslau, Silesia, sixty-one years ago, he served a pharmaceutical apprenticeship in the town of Schreiberhau and later studied at the University of Berlin, graduating in 1922. He followed this with postgraduate training which, in 1925, resulted in the award of a Ph.D. He later studied bacteriology at the Robert Koch Institute in Berlin. The pre-war political situation in Berlin forced him and his family to leave Germany for Great Britain.

As a research worker he had become associated with Prof. Sabaletschka after the latter had introduced the now well-known esters of *p*-hydroxy-benzoic acid. Their association resulted in establishing these compounds under the trade names of 'Nipa Esters' as extremely useful, reliable and non-toxic preservatives for pharmaceutical and medicinal products and for foodstuffs. In 1938 these two workers showed that esters of gallic acid showed very promising anti-oxidant activities; this led to the widespread use of propyl gallate as an anti-oxidant for animal fats to prevent or retard rancidity. Its proved non-toxicity was recognized in 1948 when the United States officially approved its incorporation in fats for human consumption, to be followed by similar recognition in Britain and elsewhere.

In 1942, Boehm showed that certain mono-aryl and mono-alkyl ethers of ethylene glycol possess bactericidal activity. Interest centred chiefly around the phenyl ether of ethylene glycol ('Phenoxetol'), which was investigated bacteriologically and clinically by Berry, Gough *et al.* It showed unusual activity against *Ps. pyocyanea* and during the War, in the early days of penicillin, when topical application to wounds was, of necessity, used, a combination of 'Phenoxetol' with penicillin widened the antibacterial spectrum of the latter and also prevented its decomposition in the wound.

Dr. Boehm was that rare combination of an able scientist and capable business administrator. He also combined rare intellectual qualities with integrity, charm and kindness, as those who had the privilege of knowing him can testify.

H. BERRY

Prof. H. Stansfield

PROF. HERBERT STANSFIELD, whose death occurred on March 14, was appointed to the chair of physics and electrical engineering at University College, Southampton, in 1912. Previously he was a lecturer in physics in the Victoria University, Manchester. In 1919 he was transferred, with other Departments of the College, from the old Hartley Building to the new site at Highfield.

Research undertaken at Southampton by various members of his staff, under his direction, was started in the late 'twenties. His main interest was in optics, particularly with modifications to the Michelson interferometer experiments on the velocity of light. One summer he co-operated with the Royal Navy on sound recordings of gunfire. Setting up his apparatus in an area where no reports were expected, many yards of photographic paper recordings from an Eindhoven string galvanometer were processed and examined, and the nil report confirmed.

Past students will remember Prof. Stansfield's very characteristic action in stroking his fountain pen on his beard in order to charge some piece of electrostatic equipment in lecture demonstrations. Another characteristic was his exceptionally dry skin. He would touch 200-V. terminals with his fingers and then to be quite sure he would moisten them and repeat the action and remark, "Yes, I am sure they are alive"!

He retired in 1932 at the age of sixty, and the opportunity was then taken to separate the Department of Electrical Engineering at Southampton from Physics, and join it with the Departments of Civil and also Mechanical Engineering in the Engineering Faculty. C. E. Chester

Mr. W. H. Searle, B.E.M.

William Searle, who was for sixty-three years fisherman collector on the staff of the Marine Biological Association of the United Kingdom, died at Plymouth on April 6, at the age of eighty-four. 'Bill', as he was affectionately known by all, must live in the memory of a great number of biologists, from all over the world, who visited the Plymouth laboratory either as research workers or students. It can be truly said that he played a very important part in the development of marine biology through his remarkable knowledge of the fauna and flora and its local distribution as far afield as Salcombe. He was able to produce almost any organism when required, though their specific names were not easy to interpret when marked by a broad Devonshire accent. Searle joined the Association's staff in December 1895, and worked tirelessly and devotedly, for many years single-handed, in small vessels which have become part of the history of marine biology, *Anton Dohrn*, *Busy Bee*, *Huxley*, *Oithona* and finally *Gammarus*, now in her thirty-seventh year.

He was elected an associate member of the Marine Biological Association in 1953. He also received the Queen's Coronation Medal; and in 1957 his services to science were recognized by the award of the British Empire Medal, of which he was very proud. He retired from service in 1958. F. S. Russell

NEWS and VIEWS

New Director of the Science Museum, London : Dr. D. H. Follett

On taking up his duties as director of the Science Museum in succession to Dr. T. C. S. Morrison-Scott (see *Nature*, March 26, p. 888), Dr. D. H. Follett will relinquish his post as keeper of the Department of Electrical Engineering and Communications in the Museum, to which he was appointed in 1957. Dr. Follett graduated from Brasenose College, Oxford, in 1929, in the honours school of physics. He then entered the firm of Adam Hilger, Ltd., where he was engaged in developing the application of photoelectric methods, particularly to spectrophotometry. At the same time he carried on part-time research in cosmic rays at Birkbeck College under Prof. P. M. S. Blackett, for which he was awarded the internal degree of Ph.D. of the University of London. He joined the Science Museum staff in 1937 as assistant keeper in the Department of Physics, in which Department he remained, apart from the war years, until 1957, his special responsibility being for electricity and acoustics. During the War he served with the Meteorological Branch of the R.A.F. Volunteer Reserve and was engaged, among various duties, on the operational development of the cathode-ray direction-finding system for locating thunderstorms. He was appointed secretary of the Science Museum Advisory Council on its reconstruction in 1951, a post which he held for six years in addition to his other museum duties. During this period he acquired a broad view of the Museum's functioning in all its aspects. Apart from his special interest in museums and the history of science—he is a Fellow of the Museums Association and a member of the British Society for the History of Science—Dr. Follett has wide interests in science generally and physics in particular. He is a Fellow of the Institute of Physics, being vice-chairman of the Education Group, a Fellow of the Physical Society and a member of the Committee of Visitors of the Royal Institution.

Research at the Ministry of Aviation : Mr. E. B. Carter

Mr. E. B. Carter, at present serving as an assistant director in the Engine Research and Development Division of the Ministry of Aviation, has been promoted to deputy chief scientific officer and appointed director of engine production. He has a wide and varied experience of research and development on all types of aero-engine, ranging from piston engines through gas turbines to ramjets and rocket engines, which will be a considerable asset to him in his new job, in an engineering sphere where development and production are very closely linked together. Mr. Carter was born in 1912 in Halifax and received his early technical training at Halifax Technical College. On completion of the mechanical engineering course, he studied machine tool practice and was appointed assistant workshop instructor. In 1936, he became workshop superintendent and lecturer at Constantine College, Middlesbrough. Mr. Carter entered the Civil Service in 1939 on his appointment as a technical assistant in the Directorate of Engine Research and Development of the Air Ministry. From that time until 1955, his London Headquarters' service in the Air Ministry, Ministry of Aircraft Production, and Ministry of Supply alternated with periods of service as resident technical officer at the Bristol, Napier and de Havilland engine companies. In 1955, Mr. Carter was appointed assistant director in charge of research and development of ramjet and liquid-propellant rocket engines for aircraft and missiles, the post he relinquishes to take up his appointment as director of engine production.

Mr. J. D. Clare

Mr. J. D. Clare has been promoted to deputy chief scientific officer and appointed director of guided weapons research and development (Air) at the Ministry of Aviation Headquarters. In his new post he will be responsible for the development of the surface-to-air and air-to-air guided weapons for the Royal Air Force and the Army. Mr. Clare graduated at the University of Birmingham in 1940. He joined the General Electric Co., Coventry, as a student apprentice and later worked in the telecommunications laboratory on many aspects of carrier telephony systems. During this time he obtained his M.Sc. In 1945 he joined Sobell Industries as head of the radio laboratory and later became assistant chief engineer responsible for both the design and development for production of commercial radio and television receivers. In 1950 he joined the Ministry of Supply

at the Radar Research and Development Establishment, Malvern, and worked on high-power precision tracking radars. On the amalgamation of the Radar Research and Development Establishment with the Telecommunications Research Establishment to form the Royal Radar Establishment, he joined the Guided Weapon Department and in 1955 he became superintendent, surface-to-air guided weapons guidance systems. In this post he has been responsible for research on new guidance techniques which now form the basis of the future systems for the air defence of the United Kingdom and the field army. He has also been responsible for the development of tracking radars and other components of the systems and for the technical co-ordination of the complete systems.

The Central Botanical Laboratory, Allahabad : Dr. E. K. Janaki Ammal

Dr. E. K. Janaki Ammal retired from the post of director of the Central Botanical Laboratory, Botanical Survey of India, Allahabad, on October 13, 1959. Dr. Janaki Ammal has been intimately associated with the reorganization of the Botanical Survey of India, first as officer on special duty (1952–53) and as director, Central Botanical Laboratory. Dr. Ammal is widely known for the "Chromosome Atlas of Cultivated Plants" which she compiled with Dr. C. D. Darlington. She is at present officer on special duty, Regional Research Laboratory, Jammu (in Kashmir State).

Dr. G. S. Puri

Dr. G. S. Puri has been appointed director of the Central Botanical Laboratory, Allahabad, in succession to Dr. E. K. Janaki Ammal. Dr. Puri has had a varied experience during his past twenty-five years of botanical career. He has done work of international recognition in palæobotany, phytogeography and ecology, and had the privilege of working with Prof. Birbal Sahni at Lucknow and Prof. W. H. Pearsall at London. He was forest ecologist at the Forest Research Institute, Dehra Dun, for about ten years and during the past three years as regional botanist of the Western Circle of the Botanical Survey of India he completed a reconnaissance survey of the vegetation of western India. Dr. Puri has published about 200 botanical papers, including two major books, the "Indian Manual of Plant Ecology" and "Forest Ecology".

The Australian Academy of Science

The following new Fellows of the Australian Academy of Science have recently been elected: Prof. A. E. Alexander, professor of applied chemistry, University of New South Wales; Prof. G. M. Badger, professor of organic chemistry, University of Adelaide; Dr. S. Fazekas de St. Groth, reader in virology, John Curtin School of Medical Research, Australian National University; Prof. K. J. Le Couteur, professor of theoretical physics, Research School of Physical Sciences, Australian National University; Dr. J. M. Rendel, chief of the Division of Animal Genetics, Commonwealth Scientific and Industrial Research Organization; Dr. F. W. G. White, chairman of the Commonwealth Scientific and Industrial Research Organization.

The Thomas Ranken Lyle Medal for 1959 was presented to Prof. E. S. Barnes, professor of mathematics in the University of Adelaide, who delivered an address on number theory, his special field of work in mathematics.

Awards of the Meldola Medal for 1959

The Meldola Medal, which is the gift of the Society of Maccabaeans, is normally awarded annually. On four occasions in the past, two candidates have been adjudged to be of equal merit in diverse fields of work and two awards were made. This year it has again been decided to make two awards of the Meldola Medal. The recipients will be Dr. J. I. G. Cadogan, Department of Chemistry, King's College, London, for his work in the field of organic chemistry, with special reference to reactions of free radicals in solution and to reactions of organophosphorus compounds; and Dr. T. C. Waddington, Department of Chemistry, University of Cambridge, for his work in the fields of physical and inorganic chemistry, with special reference to thermochemistry and reactivity of azides; photoconductivity of anthracene; lattice energies and infra-red spectra of inorganic salts; and liquid hydrogen chloride as an ionizing solvent.

The Food Research Advisory Committee

Mr. J. B. Godber, Joint Parliamentary Secretary to the Ministry of Agriculture, Fisheries and Food, recently stated that the Minister and the Secretary of State for Scotland had set up a committee, under the chairmanship of the Permanent Secretary of the Ministry of Agriculture, Fisheries and Food, to assist them in advising the Agricultural Research Council on priorities in Government food research. This was in a written answer to a question in the House of Commons as to the arrangements for ensuring that the technical problems of the food industry are brought to the notice of the Agricultural Research Council now that the Council is responsible for the three Government research stations concerned with the handling and processing of foodstuffs. The Committee would be known as the Food Research Advisory Committee and its terms of reference would be: "To advise on those food problems (except for fish, which is dealt with separately) requiring investigation or research which should be undertaken with the aid of public funds and to make recommendations as to the priorities to be accorded to such problems". In addition to the chairman, Mr. E. Capstick, Dr. D. P. Cuthbertson, Sir Charles Dodds, Mr. J. D. Hutchison, Mr. D. Lowe, Mr. A. Sainsbury, Sir William Slater, Dr. J. A. B. Smith, Mr. T. A. H. Sycamore, Mr. J. P. Van den Bergh, Sir George Wilson and Mr. N. Wood had accepted invitations to be members of the Committee.

Ford Research Fellowships in Animal Reproduction

The Ford Foundation has made a grant of 550,000 dollars (£196,000) to the Zoological Society of London to endow a series of research fellowships in animal reproduction. Our present knowledge of reproductive processes is derived mainly from observations on a limited number of species, such as rats, mice, rabbits, guinea pigs, monkeys, and farm animals; but it is sufficient to show that there is great diversity in reproductive mechanisms. We know that some species are continuous breeders and that others are seasonal; that some animals ovulate spontaneously and that others do so only as a result of various forms of external stimulation. These differences have always served as pointers to research, which has in turn

revealed issues which are vitally important to the control of reproduction. The animal collections maintained by the Society at Regent's Park and Whipsnade constitute the richest assemblies of living vertebrates in the world, and the Society also has in its possession breeding records which go back to the year 1828. The resources of the Society, however, have never been sufficient to promote a proper and continuing investigation of breeding behaviour.

Those appointed to the research fellowships, of which there will be six—three senior and three junior fellowships—will be expected to undertake systematic studies of the reproductive habits and the physiology of animals. It is hoped that they will have a secondary attachment to a university department or to a research institute in which reproductive physiology is a major research interest. Laboratories will be provided at Regent's Park by the Zoological Society, and a Breeding Research Committee, including British scientists who are in the forefront of research into reproductive physiology, has been established to supervise the work. Among those serving on the Committee are Prof. E. C. Amoroso, Prof. F. W. Rogers-Brambell, Prof. A. St. G. Huggett and Dr. A. S. Parkes.

The Beit Memorial Fellowships

The trustees of the Beit Memorial Fellowships for medical research have announced the following elections: *Junior Fellowships* (£900 *a year*), D. C. Watts, to study the mechanism of enzymes in muscle from animals of various species and especially the role of the sulphydryl groups thought to be necessary for enzyme activity (at the Department of Biochemistry, University College, London); J. R. Casley-Smith, to investigate the ultra-structure and properties of the endothelium of lymphatics, in health and disease, with special reference to dropsy (at the Sir William Dunn School of Pathology, Oxford); P. F. Fottrell, to investigate the mechanism of adaptive enzyme formation in normal and malignant animal cells maintained in tissue culture (at the Tissue Culture Laboratory, Biochemistry Department, University of Glasgow); A. J. Rowe, to study the properties of the contractile muscle protein myosin, by means of the electron microscope (at the Department of Colloid Science, Cambridge); Dr. G. F. V. Seaman, to study the relationship between the chemical composition of the human red blood corpuscle membrane and its electrokinetic charge as determined by microelectrophoresis (at the Department of Medicine, Cambridge). *Senior Fellowship* (£1,300 *a year*), Dr. J. R. Tata, to purify and isolate thyroxine dehalogenase from various tissues and to investigate the relationship between metabolic transformation of thyroid hormones and their action in an isolated system (at the National Institute for Medical Research, Mill Hill, London).

Paul Instrument Fund Awards

Awards of grants by the Paul Instrument Fund Committee have been made as follows: £2,500, with the probability of further grants totalling up to £3,000, to Dr. J. H. Sanders, university lecturer and demonstrator in physics, Clarendon Laboratory, Oxford, for the construction of an optical maser; £3,000 to Mr. H. W. Gosling, lecturer in the Department of Engineering, University College of Swansea, for the construction of an instrument for checking the stability of the standard ampere. The Paul Instrument Fund Committee, composed of representatives of the Royal Society, Physical Society, Institute of Physics and Institution of Electrical Engineers, was set up in 1945 "to receive applications from British subjects who are research workers in Great Britain for grants for the design, construction and maintenance of novel, unusual or much improved types of physical instruments and apparatus for investigations in pure or applied physical science".

Co-operative Research in Europe

A short article, "O.E.E.C. and the Scientific Future", in the February issue of *European Productivity* notes some of the ways in which the Organization for European Economic Co-operation has been strengthening the scientific resources of Europe. First, the Organization is pursuing an inquiry into the scientific policies of member countries and their research resources, such as a study of fiscal measures which influence investment in industrial research. Secondly, co-operative research is in progress on fatigue failure in metals and the fouling of ships' hulls; representatives from Sweden and Yugoslavia joined the group of experts this year and the adhesion of Yugoslavia will make it possible to secure a better picture of fouling organisms in Mediterranean waters. Tests are still being made in Europe, Australia, North America, South Africa and Singapore, and a catalogue of the biological and hydrological characteristics of the testing stations in use will be published. Experts from nine European countries and the United States have met to plan co-operative research into aircraft noise and have recommended free exchange of all available information on aircraft noise and its effects, particularly its biological effects on people living near airports. A permanent group has been set up to advise the Committee on Applied Research on the long-term development of research into the abatement of aircraft noise. A group of nine member countries dealing with fire research is proposing to study unstable chemicals for plastics and also fire-fighting techniques and materials, while other work is in hand on the industrial utilization of oil-shale fires, the measurement of air pollution, static electricity in industrial tools, road safety and production engineering techniques. Thirdly, attention is being given to the supply of scientific and technical personnel in relation to Europe's economic needs, including such matters as the use of television in science teaching, and methods of teaching mathematics in schools.

British Library of Political and Economic Science

The annual report of the British Library of Political and Economic Science for 1958–59 records little change in the funds available for purchase or in book prices; but acquisitions of Russian publications were slightly lower than in 1957–58 and were facilitated by exchange arrangements with the Saltykor-Shchedrin Public Library, Leningrad, the Lenin Library, Moscow, and the All-Union Library of Foreign Literature (pp. 16. London: British Library of Political and Economic Science, 1959). Additions during the year included 5,330 treatises, 1,510 pamphlets, 2,386 non-serial government publications and 8,235 current serials, including 5,913 periodical titles received as gifts from governments, municipalities, institutions and societies. Of the Library's total holdings of 401,752 bound volumes, 12,137 were in the Lending Library and 4,674 in the Shaw Library.

The Manchester Museum

THE annual report of the Manchester Museum for 1958–59 records that the year has been notable for the continuation of the policy of the Committee to modernize display and provide showcases with internal lighting, the receipt of a number of valuable acquisitions including the Raby collection of coins and the Armstrong collection of bones and artefacts from Pin Hole Cave, Derbyshire, and the mounting of a series of exhibitions in the special gallery devoted to this purpose (pp. 20. Manchester: The Manchester Museum, The University, 1960). These latter included the R. W. Lloyd Japanese Collection and the Robinow Collection from ancient Egypt. During the year two departmental guides, devoted to ethnology and mammals, were published. It is also reported that the University has allocated certain funds for the conversion of the Archæological Balcony into a complete gallery, part of which can be used for the R. W. Lloyd Japanese material. The building programme of the University has made it possible for the Department of Zoology to relinquish the accommodation adjoining the Herbarium, and this is to be used for a much-needed botanical laboratory, an office and for storage.

Geological Surveying by Helicopter

UP to about 1950, after more than a century of effort, only about a third of Canada's 3·6 million square miles of land had been mapped geologically even on a reconnaissance scale. Conventional field work in increasingly remote regions was becoming prohibitively slow and costly, and insufficient trained geologists were available to carry out intensive pioneer explorations comparable to the all-out Russian efforts in Siberia. Clearly a radically new field technique was required to meet the urgent need for geological exploration, development and exploitation in the north. In a recent publication officers of the Geological Survey describe how this new technique has been found in the widespread use of helicopters (Canada: Department of Mines and Technical Surveys. Geological Survey of Canada. Bulletin No. 54: Helicopter Operations of the Geological Survey of Canada. By Officers of the Geological Survey of Canada. Pp. xii + 60 + 7 plates. (Ottawa: Queen's Printer, 1959.) 75 cents). Seven major helicopter-supported geological surveys, instituted as experiments between 1952 and 1958, have covered close on half a million square miles—half as much ground as had been mapped in the previous 110 years. While these helicopter operations have afforded maps on the scale of 1 in. to 8 miles (1 : 506,880) instead of the 1 in. to 4 miles common in conventional reconnaissance, they have given more uniform coverage and more speedy results at an operating cost (in the region of 1·68–3·63 dollars per square mile) less than that of any other field method known. The rapid progress is indeed remarkable; but Canada still has some considerable way to go before it overtakes the U.S.S.R., now almost completely mapped on scales of between 1 : 500,000 and 1 : 1,000,000, and producing on a scale of 1 : 200,000 between 120 and 150 map-sheets per annum.

Fate of Bacteria in the Small Intestine

RECENT work carried out by J. M. S. Dixon, of the Public Health Laboratory, Cardiff, confirms the view that the empty small intestine of healthy persons contains only a few transient organisms, even when free acid is absent from the stomach (*J. Path. and Bact.*, **79**, No. 1; January 1960). The small gut appears to possess some antibacterial mechanism causing organisms that escape destruction in the stomach to be either destroyed or removed from the lumen before they can multiply. There has been some disagreement as to whether the small intestine is relatively free from organisms because of destruction of bacteria within the lumen or because peristaltic activity removes the bacteria before they can multiply. The *in vivo* experiments were designed to elucidate this point. Test organisms were inoculated directly into subcutaneously displaced loops of small intestine of non-anæsthetized rats together with an inert unabsorbable marker. The animals were killed after periods of time and the number of bacteria and quantity of marker present in regions of the small gut determined. The marker used was a radioactive isotope of chromium which, when tagged to red blood cells, is virtually unabsorbed from the intestine. The results of twenty-eight bacterial inoculations indicated that bacteria were rapidly moved onward and soon removed from the small intestine by peristaltic action. There was no indication of bactericidal action. Mechanical removal by peristaltic action, aided by the secretion of mucus, is probably the main fate of viable organisms that enter the small intestine.

Cave-dwelling Shrimps

THE Australian Museum announces that it has acquired from the Milyering district, Western Australia, some freshwater shrimps of considerable interest to zoologists (*Aust. Mus. Mag.*, **13**, No. 3; 1959). The specimens were collected by Mr. A. Snell, of Bunbury, West Australia, in the dark recesses of a well bored through coral and limestone country. The shrimps lack sight and have been identified as true troglodic (cave-dwelling) forms—the first to be recognized from the Australian continent, and not previously recorded. The task of providing the shrimps with a zoological name and preparing a description of them for publication in the *Records of the Australian Museum* is being undertaken by Dr. Lipke Holthuis, of the Leyden Museum, Holland.

Large Pine Weevil

THE first of the leaflets published by the Forestry Commission has now been issued in revised form and illustrated with attractive colours (Forestry Commission Leaflet No. 1: The Large Pine Weevil (*Hylobius abietis*). Revised edition. Pp. 11. London: H.M. Stationery Office, 1960. 1*s*.). It deals with the large pine weevil, *Hylobius abietis* L., which is the only species of the genus *Hylobius* of importance in coniferous forests in Britain. It feeds on the bark of young coniferous trees, and, where it is unduly numerous, may cause the complete loss of a newly planted crop. Recent trials, both in Great Britain and abroad, have shown that it is possible to provide protection to young crops by the direct application of various insecticides. Two possible situations may arise—that in which the weevil attack is anticipated, and that in which the weevil attack occurs unexpectedly. In the former case, the dipping of planting stock before planting out should be used; but in the latter the young crop should be sprayed as soon as the attack develops. With both types of treatment the insecticide recommended for use is DDT. The main factor controlling the numbers of *Hylobius* is the availability of suitable breeding sites. When breeding grounds are provided by fellings or

by natural catastrophes such as fire or wind-blow, numbers inevitably rise. Some control of weevil increase is afforded by insect parasites, such as *Bracon hylobii* Ratz. and *Ephialtes tuberculatus* Geoff. in Four., by fungal attack on larvæ and possibly by birds. Generally, this natural control is unable to keep populations below a density at which they can cause serious damage to young conifer crops.

The Nucleus in a Basidiomycete

A. Bakerspigel has given a detailed account, with numerous photographic illustrations, of the structure and manner of division of vegetative hyphal nuclei in *Schizophyllum commune* (*Canad. J. Bot.*, **37**, No. 5, 835; 1959). These nuclei do not divide in a manner directly comparable to ordinary mitosis. During division the tightly packed chromatinic granules become loosely arranged, after which they contract into a densely stained bar. As division proceeds, this bar of chromatin elongates and then constricts at its mid-region. At the end of division the extremities pull apart quickly to form the chromatin portions of the two sister nuclei. The Feulgen-negative central bodies decrease in size, and at the end of division their remnants lie free in the cytoplasm. New central bodies arise in the maturing sister nuclei. Throughout division, metaphase plates, spindles, or individual chromosomes were not observed in any of the stained or living preparations. A nuclear membrane has not been observed surrounding any of these nuclei.

Anchiceratops from Alberta

A natural history paper by Mr. Wann Langston, jun. (No. 3; September 23, 1959), published by the National Museum of Canada, deals with specimens of *Anchiceratops* from the Oldman formation of Alberta. This is an Upper Cretaceous bed, and the material was collected by a National Museum expedition of 1937. The paper describes fully the specimens in the Museum and discusses the habitat of *Anchiceratops* and the characteristics of the sediments in which they are found.

Miniature Gyroscopes

In the first of a series of articles devoted to micro-instruments, W. R. Simons of Smiths Aircraft Instruments Ltd., describes the use of miniature gyroscopes in aircraft and guided missiles (*Research for Industry*, **13**, No. 2; February, 1960). The special requirements of guided missile control systems and recent developments in the design of aircraft auto-pilots have created a demand for miniaturized gyroscopes, possessing high accuracy together with exceptional reliability and robustness. Some of the fundamental problems associated with the design of these miniature gyroscopes are discussed and typical examples of the instruments are described.

Bibliography on Plasma Physics and Magnetohydrodynamics

Though the subject of magnetohydrodynamics dates back to the nineteenth century, it is primarily in the past two decades that it has attracted wide attention. Its importance, first recognized in astrophysics, has spread to many fields, particularly the study of the flow of gases and the appearance of ionization, and the phenomena presented by completely ionized plasmas at extremely high temperatures. The literature on the subject has increased at a rapid rate, and we are indebted to J. D. Ramer, of the Engineering and Physical Sciences Library of the University of Maryland, for the collection of literature of the period 1937–59 which he has compiled (Bibliography on Plasma Physics and Magnetohydrodynamics and their Applications to Controlled Thermonuclear Reactions. Pp. ii+105. College Park, Maryland: Engineering and Physical Sciences Library, University of Maryland, 1959). The bibliography contains 1,707 references arranged alphabetically by authors. In general, the titles of the papers are given in English, but the language of the original article is quoted. The author index seems superfluous (it covers twelve pages), but together with the numerical index to Atomic Energy Reports (five pages) and the alphabetical list of journals referred to in the bibliography (four pages) which complete the volume, it gives an excellent impression of the wide and useful coverage of the bibliography.

Scholarships in Chemical Engineering

Constructors John Brown, Ltd., have entered into an agreement with the Institution of Chemical Engineers for the award of two scholarships. The purpose of the scholarships is to encourage research in chemical engineering and, in particular, in chemical plant design. The scholarships are tenable at any educational institution in the United Kingdom in receipt of grants from the University Grants Committee, and having a department of chemical engineering under the direction of a professor of chemical engineering. Further information can be obtained from Dr. J. B. Brennan, Institution of Chemical Engineers, 16 Belgrave Square, London, S.W.1. Applications should reach the Institution not later than June 1.

University News: Birmingham

The following appointments to lectureships have been made: Dr. G. H. Burkhardt (mathematical physics); Dr. D. C. Champeney (physics); Mr. D. A. O'Connor (physics); Dr. M. J. Lawrence (genetics); Mr. G. H. Trengrouse (mechanical engineering); and Mr. E. Amini (mechanical engineering).

Edinburgh

A chair of electrical engineering has been instituted in the University of Edinburgh and applications for appointment to it will shortly be invited.

London

Dr. K. W. Cross, reader in physiology at St. Mary's Hospital Medical School, has been appointed to the University chair of physiology tenable at the London Hospital Medical College. Dr. B. C. L. Weeden, reader in organic chemistry at the Imperial College of Science and Technology, has been appointed to the University chair of organic chemistry tenable at Queen Mary College. Dr. D. V. Ager, lecturer in geology at the Imperial College of Science and Technology, has been appointed to the University readership in geology tenable at that College. The title of reader in the history and philosophy of science in the University of London has been conferred on Dr. N. H. de V. Heathcote in respect of his post at University College.

The following elections to fellowships of the Imperial College of Science and Technology have been made: Sir Harold Roxbee Cox, director, Wilmot Breeden (Holdings), Ltd., the Metal Box Company, etc., former special lecturer in aircraft structures;

Prof. C. W. Dannatt, professor emeritus, former professor of metallurgy and former dean of the Royal School of Mines; Prof. F. G. Gregory, professor emeritus and former professor of plant physiology; Mr. G. C. Lowry, former secretary of the College; and Sir William Pugh, director of the Geological Survey and Museum, member of the Governing Body.

Announcements

MR. J. B. ADAMS, at present director of the Proton Synchrotron Division of the European Organization for Nuclear Research (CERN), has been appointed interim director-general of the Organization; this appointment became necessary as the result of the recent death in an aeroplane accident of Prof. C. J. Bakker. Mr. Adams was recently appointed director of the new Controlled Thermonuclear Research Establishment in the United Kingdom, but will remain with CERN until later this year.

DR. W. F. FLOYD, senior lecturer in physiology at the Middlesex Hospital Medical School, University of London, has been appointed to be first head of the Department of Ergonomics and Cybernetics at Loughborough College of Technology. Dr. Floyd will assume his appointment at Loughborough in September.

DR. H. D. KAY, director of Twyford Laboratories, Ltd., Twyford Abbey Road, London, N.W.10, announces the following appointments: Microbiology Section, Dr. C. Elizabeth Work, who has carried out research in the Department of Chemical Pathology, University College Hospital Medical School, London; Dr. Work will be assisted by Dr. V. A. Knivett, formerly of the Microbiology Section of the National Chemical Laboratory (Department of Scientific and Industrial Research), Teddington. Biochemistry Section, Dr. J. Leggett Bailey, recently at the Rowett Research Institute, Aberdeen; he will be assisted by Dr. R. J. Sturgeon, of the Research and Development Department at Epsom of the Distillers Company, Ltd.

THE sixth annual Guenter Loeser Memorial Lecture will be given by Dr. Hans E. Hinteregger on "Solar Extreme Ultra-violet Radiation as a Source of Interplanetary Ionization". The Lecture, organized by the U.S. Geophysical Research Directorate, will be given in the Lexington High School Auditorium, Lexington, Massachusetts, on June 1. Further information can be obtained from Arnold M. McCalmont, Geophysical Research Directorate, Air Force Cambridge Research Center, Bedford, Mass.

THERE will be open days at the National Physical Laboratory, Teddington, on May 25 and 26. The new Ship Hydrodynamics Laboratory at Feltham (see *Nature*, **184**, 926; 1959) will be open to inspection for the first time.

THE seventy-fifth anniversary exhibition of the Royal Scottish Geographical Society, entitled "Mapping Britain", is being held in the Royal Scottish Museum, Chambers Street, Edinburgh, during May 14–June 25. Further information can be obtained from the Secretary of the Society at Synod Hall, Castle Terrace, Edinburgh 1.

THE second Congress on Catalysis is to be held in Paris during July 4–9. Further information can be obtained from Prof. G. Emschwiller, 10 rue Vauquelin, Paris 5°.

THE eleventh International Astronautical Congress is to be held in Stockholm during August 15–20 under the auspices of the Swedish Interplanetary Society. Further information can be obtained from the Congress Information and Publicity Committee, *IAF*-60, Box 5045, Stockholm 5, Sweden.

AN International Conference on Scientific Problems of Crop Protection, sponsored by the Hungarian Academy of Sciences, will be held in Budapest during July 19–22. Further information can be obtained from Z. Király, Research Institute for Plant Protection, Budapest.

AN International Congress on Photobiology is to be held in Copenhagen during July 31–August 5 under the auspices of the International Committee of Photobiology. Further information can be obtained from Dr. B. Chr. Christensen, Finsen Memorial Hospital, Strandboulevard 49, Copenhagen Ø.

THE sixth Commonwealth Conference on Mycology will be held at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1, during July 15–23. Further information can be obtained from the Commonwealth Mycological Institute, Ferry Lane, Kew, Surrey.

The fourth International Conference on Goitre is to be held at Church House, Great Smith Street, London, S.W.1, during July 5–9. Further information can be obtained from the honorary secretary, Dr. Selwyn Taylor, 67c New Bond Street, London, W.1.

A CONFERENCE on heat treatment practice, organized by the British Iron and Steel Research Association, will be held at Harrogate during July 5–6. Further details can be obtained from the Technical Secretary, Metallurgy (General) Division, British Iron and Steel Research Association, 11 Park Lane, London, W.1.

AN International Congress of Endocrinology, the first of its kind, is to be held in Copenhagen during July 18–23. Further information can be obtained from the Congress Secretariat, Dr. Svend G. Johnsen, Hormone Department, Statens Seruminstitut, Copenhagen S, or the general secretary, Prof. F. T. G. Prunty, Department of Chemical Pathology, St. Thomas's Hospital Medical School, London, S.E.1.

THE annual meeting and summer conference of the Society for Applied Bacteriology will be held at Bangor during July 5–7. Further information can be obtained from Dr. Ella M. Barnes, Low Temperature Research Station, Downing Street, Cambridge.

THE third International Conference on Medical Electronics and associated scientific exhibition are to be held at Olympia, London, during July 21–27. The conference is being organized jointly by the Electronics and Communications Section of the Institution of Electrical Engineers and the International Federation for Medical Electronics. Further information can be obtained from the Conference Secretariat, Institution of Electrical Engineers, Savoy Place, London, W.C.2.

A NEW list of medical and technical papers prepared by research workers has just been issued by Cyanamid International in London. The current range of subjects covers the trial administration of Lederle Laboratories' oral polio vaccine in many different countries and papers on specialty industrial chemicals. These paper are available from the Cyanamid International Information Service, 16 Bolton Street, London, W.1.

INHALED PARTICLES AND VAPOURS

THE British Occupational Hygiene Society held an international symposium under this title at Oxford, during March 29–April 1, when 38 papers were read. Inhalation of foreign substances in the atmosphere has never before been discussed on such a scale, and the gathering of 250 scientists from 19 nations enjoyed a unique presentation of most of the basic and a few of the applied aspects of the subject.

Six of the papers dealt with the deposition, translocation and effects of radioactive particles.

Papers on the mechanics of breathing included a study of maximal flow-rates, a consideration in designing respiratory equipment, and a demonstration that turbulent flow could be detected at the exit of a segmental bronchus with high air-flow. During gentle breathing the larynx probably causes some turbulence which is passed down the trachea when inhaling; even at high rates turbulence is not fully developed and cross-stream mixing is far from complete.

The mixing of tidal and alveolar air had been investigated with a half-micron aerosol as a tracer. The particles in this have practically no diffusion constant, and no rate of fall, so that they follow the mechanical movements of inspired air and reveal, by wash-in and wash-out analyses, the gas-phase exchange properties of the lung which cannot be demonstrated by even high molecular weight gases since they diffuse too quickly. This exchange is important in the deposition of aerosols in the lungs, which is further complicated by the desirability of distinguishing alveolar from bronchial epithelial deposition since only the former contributes to the pneumoconioses.

Previous approaches to the problem have been made by calculating the motion of particles in the airways; a formalized anatomy of the human lung for use in such calculations, and in expressing the fluid mechanics of gas-flow, was put forward at the meeting.

The loss of particles during inhalation was shown to be affected by their increase in size by absorbing moisture, while passing through the respiratory tract, which also results in their being less likely to penetrate deeply. Tobacco smoke has a high retention, in view of its initial particle size, for this reason, and sodium chloride crystals increase about 350 times in volume.

Sulphuric acid droplets behave similarly and are important in atmospheric pollution. The oxidation of sulphur dioxide, which dissolves rapidly in aqueous droplets, is promoted catalytically by trace contaminants in the liquid phase, and may be a factor in the relationship of atmospheric sulphur to human respiratory distress.

An increase in the response of guinea pigs to irritant gas, expressed as a rise in respiratory resistance measured with an intrapleural catheter, referred to tidal volume indicated by a body plethysmograph, was found to result when an inert aerosol of sodium chloride was inhaled along with sulphur dioxide or formaldehyde. The particle size had to be around 0·1μ in diameter, 2·5μ aerosol giving no potentiation. A physical explanation was advanced for this effect, based on the absorption of the gas by the particles so that the uptake on respiration was localized at discrete places on the bronchial surface instead of being diluted over a large area. This observation has not yet been confirmed in man.

The absorption of vapours during inhalation is subject to three possible rate-determining factors which can be expressed as a simple mathematical model. They comprise the rate of lung ventilation, the diffusion capacity across the lung wall, that is the gas-liquid boundary, and the rate of flow of the pulmonary blood allowing for the air–water partition coefficient of the foreign gas.

According to circumstances one or other of these factors predominates to control the build-up in tissue during exposure and the subsequent drainage, when the breathing of pure air is resumed. The three main storage depots recognized are viscera, connective tissue including skin and muscle, and body fat, between which the flow of blood is apportioned in the ratios 73 : 24 : 3. Allowing for tissue mass and fat–water partition it can be shown, in contrast to carbon monoxide, which is all held in the blood, that nitrogen is stored and that the equilibration-rate for fat is very slow so that a reservoir is formed and may result in the initiation of caisson disease.

A soluble vapour was shown, in experiments on the uptake of inhaled sarin (*iso*propylmethylphosphonofluoridate) in animals and man, to be absorbed in the nose and in the mouth and throat at low rates of oral inhalation; at high rates it penetrated to the lungs. Human nasal retention of particles was found to be practically complete at 9μ diameter, falling to 10–20 per cent at 0·4μ. The reason for this appreciable retention at the small size is obscure. Ammonia and iodine were entirely absorbed in the nose.

The elimination of dust deposited in the acinus of the animal lung was the subject of several papers. Some dust is eliminated via the ciliated epithelium while the rest penetrates the interstitial tissue and may reach the lymphatics. The view was put forward that phagocytes originating from the alveolar wall are responsible for the carriage of dust from the acinus to the mucus escalator which ends at the base of the terminal bronchioles, each of which feeds an acinus, the latter constituting the basic respiratory units of the lung. Only free, not phagocyted particles could enter the interstitium, the route being by means of the transition region between the acinus and the terminal bronchiole; the pick-up by the mucus escalator from the respiratory bronchioles is regarded as being incompletely effective.

Experiments were described showing that elimination from the alveoli is a slow and continuous process. The proportion of deposited dust following the lymphatic route depended on the kind of dust, and repetition of exposure stimulated elimination and mobilized existing dust deposits. Experiments on exposures to red and black dusts, with a time-interval between, proved that dust was conveyed, probably by phagocytes, to collection sites around the air passages and that these foci were not static structures,

but the particles continually shifted about, as could be explained by the repeated death of dust-laden phagocytes with release of their burden, which was then incorporated by new cells.

After a single administration of dust, phagocyte counts in saline washed into and out of rat lungs demonstrated that the number of cells was related to the quantity of dust eliminated. The half-life of this phase of elimination by phagocytosis to the bronchial epithelium was about 17 hr. The proportion of dust eliminated in this way depended on the nature of the dust, but the time-constant did not; it did not appear to matter whether the dust was given by inhalation or by intratracheal injection.

Another series of experiments confirmed the destructive action of silica dusts on macrophages and once again led to the suggestion that the damage inflicted on the cells is the first step in the chain of causation of silicosis. The effect is believed not to be cytotoxic, but to comprise an activation either of a serum complement absorbed on the outside of the cells or of an enzyme, possibly a non-specific esterase, within the cells.

Examination of lung residues from 50 asbestosis cases was reported, with the conclusion that a fibrogenic agent was liberated when asbestos bodies break up. The deposition of an asbestos fibre in lung tissue is followed by its becoming enclosed in a protein sheath which passes through a sequence of changes and finally segments, after 10–15 years, with fracture of the contained fibre. The fragments of the sheath are collected by interstitial macrophages and fibrosis is marked in regions where this occurs. The time sequence of clinical events and of lung content of fibres exceeding 26μ in length supports the argument.

Papers on dust-sampling included the description of an ingenious centrifugal device called the 'conicycle', which collects only particles between upper and lower limits of falling speed. It has been engineered as a practical sampling tool for coal mines and is being tried out underground.

The relationship between the acceptance curve of a sampling instrument designed to control dust conditions relevant to the incidence of pneumoconiosis, and the actual deposition–particle-size curve of the human respiratory tract was given more emphasis by the engineers than our crude and incomplete knowledge of the latter can possibly justify.

Arguments in favour of selecting finer particles than the 50 per cent at 5μ diameter and unit density, which at present forms the basis of British selective sampling practice, are therefore poorly based. The opposite view was also put forward, that all dust should be sampled, irrespective of particle size; besides being physically impossible this would encourage the collection of large quantities of coarse dust which has no conceivable bearing on pneumoconiosis because, when inhaled, it would not penetrate beyond the bronchi, and larger bronchioles.

The papers and discussions will be published by Pergamon Press in due course.

C. N. Davies

CARDIOVASCULAR EFFECTS OF NICOTINE AND OF SMOKING

During March 23–25 a symposium on the Cardiovascular Effects of Nicotine and of Smoking was held by the New York Academy of Sciences. The papers presented covered more than the cardiovascular effects and included other interesting observations. For example, nicotine is found not only in the tobacco plant, but it also occurs widely in the plant kingdom. It is produced in the root system of the tobacco plant, and the growth of the roots is very closely related to the rate of nicotine production, from which R. F. Dawson (Columbia) and his colleagues conclude that the same reaction step limits both processes. Nicotine arises from the precursors nicotinic acid and ornithine. From the root it is transported primarily to the leaves, where it accumulates during the active life of the plant. It is believed to be a terminal product with no appreciable physiological activity for the plant. Such a conclusion seems to an animal physiologist to be highly unlikely.

Nicotine is absorbed not only by those who smoke but also by those who take snuff and those who chew tobacco. The figures given for the amount of nicotine absorbed when smoking one cigarette vary according to the degree to which smoke is inhaled. They range from estimates as low as 0·3 mgm. to others as high as 1·8 mgm. Since the intravenous injection of 0·7 mgm. nicotine (base) produces unpleasant symptoms, the higher figures must be regarded with doubt.

Nicotine taken in the form of snuff has been estimated to amount to 20–60 mgm. a day, and that absorbed as a result of chewing has been estimated as 10–90 mgm. a day (Larsen, Richmond, Virginia). It is obvious that the taking of snuff and the chewing of tobacco offer much less risk of producing cancer of the lung.

The metabolism of nicotine is not yet fully known, and further work is badly needed. Nicotine is found in the urine excreted unchanged, together with related substances (McKennis, Richmond, Virginia). Oxidation of the pyrrolidine ring appears to be a major step. The lactam (−)-cotinine which arises from the metabolism of (−)-nicotine is oxidized, and in the dog there is hydroxylation and methylation. It seems possible that the metabolism of nicotine changes with advancing years, some processes declining in rate or ceasing altogether. If the toleration of nicotine depends on a high rate of breakdown, the observation that some older people stop smoking who smoked much when young may depend on such a decline.

Nicotine has been known to cause poisoning in those using it as an insecticide. Travell (Cornell) has shown that its absorption through the skin is greatly affected by the *p*H of the solution. At a *p*H of 5·0 or less it is very little absorbed, but at an alkaline *p*H it is readily absorbed. This holds true for the membrane of the stomach and of the bladder. Nicotine excreted in the urine may be absorbed from the bladder into the blood if the urine is alkaline, and may produce toxic effects. The speed of absorption depends on the concentration of free base. On the cardiovascular system, nicotine has long been believed to owe its action to stimulation of the

autonomic ganglia. Langley applied nicotine to ganglia in order to determine the effect of stimulating the cells present in the ganglia. Recently, attention has been directed to various peripheral effects of nicotine at sites where ganglia are not present. Thus, nicotine has a two-fold effect in the isolated heart. It causes first inhibition of contractions, and second acceleration and augmentation. The inhibition is excluded in the presence of atropine, but the acceleration is unaffected. In the heart there is a store of noradrenaline which can be extracted from the heart. Hitherto the existence of this store has been neglected by physiologists. It is now evident that the acceleration of the heart caused by nicotine is due to the release of some of the noradrenaline from the store. This follows from the observation that when there is no store of noradrenaline, nicotine loses its accelerating action (Burn and Rand, Oxford). Treatment of the animal with reserpine causes a disappearance of the store at the end of a few hours. The rise in heart-rate which follows smoking is thus probably explained by an action of nicotine on the heart itself releasing noradrenaline from storage sites in the heart.

In 1940 it was shown by Grace Roth and her colleagues that when a person smoked a cigarette in a warm room there was a large fall in skin temperature. This fall was believed to result from a constriction of the skin vessels caused by a stream of impulses passing down the vasoconstrictor nerves. However, observations have recently been made in the isolated ear of the rabbit, which contains no ganglia. These have shown that when the vessels of the ear are perfused with a modified Ringer's solution, the outflow being measured with a sensitive recorder, the injection of 3 μgm. of nicotine into the fluid about to enter the ear causes vasoconstriction. The outflow from the ear veins is greatly reduced. This action also appears to be due to the release of noradrenaline from a store present in the ear, either in the walls of the vessels or in tissue nearby. For if a rabbit is injected with reserpine on one day, and then killed on the following day, the noradrenaline which can be extracted from the skin of the ear has disappeared, and when the ear is perfused with Ringer's solution, nicotine no longer causes vasoconstriction. When the skin of such an ear is extracted, no noradrenaline is found present in it. Some individuals suffer from a disease called thrombo-angiitis obliterans which when active causes such a restriction of the circulation through the fingers that the tissues become dry and bloodless, and the finger tips may become gangrenous. The disease may be quiescent for long periods; but if the patient begins to smoke, the symptoms get worse and the disease becomes active. It seems likely that the effect of smoking is explained by nicotine releasing noradrenaline from the neighbourhood of the small vessels.

The exact site of storage of noradrenaline in the heart and in or near the vessels is unknown. There is a possibility that it is held in tissue known as chromaffin tissue. These are cells which stain brown with potassium dichromate; they form the greater part of the cells of the adrenal medulla. Such cells have long been known to occur among the fibres of the sympathetic system, and side by side with the sympathetic ganglion cells. They originate in the neural crest like the sympathomimetic ganglion cells and were called by Kohn "paraganglia" in 1903. Evidence is beginning to accumulate that the distribution of chromaffin cells is much wider. Busacchi in 1912 described a "paraganglion cardiacum" lying around the origins of the coronary arteries. Adams-Ray and Nordenstam (1956) have described such cells in human skin, and Leach believes that they may be present in the skin of the rabbit ear, in the skin of the cat's tail and in the nictitating membrane of the cat's eye. In all these situations nicotine exerts an action on the normal tissue. Thus, as already mentioned, nicotine causes constriction of the vessels of the rabbit ear; it also causes erection of the hair on the cat's tail, and finally it causes contraction of the nictitating membrane when isolated from the body and free from ganglia. Yet if an animal is previously treated with reserpine, and if in consequence all local stores of noradrenaline disappear, nicotine loses these actions, and all the chromaffin cells are lost. It may therefore be that nicotine exerts its peripheral effects by discharging noradrenaline from chromaffin cells.

J. H. Burn

THE NEW ZEALAND ANTARCTIC EXPEDITION

In the thirty-third Thomas Cawthron Memorial Lecture, Sir Edmund Hillary described some of the experience gained by members of the New Zealand Antarctic Expedition (Cawthron Institute, Nelson, New Zealand. Thomas Cawthron Memorial Lecture No. 33 (1958): The New Zealand Antarctic Expedition. By Sir Edmund Hillary. Pp. 12+4 plates. Nelson: Cawthron Institute, 1959). Although, for economy, the expedition made use of Ferguson tractors, Sir Edmund records that, with three 'Snocats', the journey could have been done "with twice the comfort and in almost half the time".

Comparison of the buildings which have been traditionally used on British expeditions and the newer module type of construction shows the advantages to rest almost entirely with the latter.

The experience gained with the dog teams should be of value to other expeditions. At the base, the dogs lived primarily on seal meat supplemented by vitamin pills, although this was varied at times with tinned dog food. In the field lightness was of primary importance and here pemmican was used. There were two forms of pemmican. One was the standard 'Bovril' pemmican which has been used a great deal in the Antarctic and the Arctic. Long and strenuous trips have been made on this pemmican, but the literature on the subject is filled with criticisms of it and descriptions of the deterioration in dog health when it is used. The Expedition's experience with 'Bovril' pemmican was much the same—loss of condition and continual scouring. "It was very fortunate that we also had generous supplies of the second type of pemmican, which was based on a formula developed by Dr. Malcolm of the Otago Medical School for the Byrd Expedition". This pemmican proved to be an outstanding success and

played an important part in the achievements of the dog teams. The formula is :

Meat meal	42 per cent
Tallow	40 ,,
Whole wheat meal	10 ,,
Wheat germ	5 ,,
Molasses	2 ,,
Cod liver oil	1 ,,

Sir Edmund Hillary indicates that dogs can still do a useful task in the Antarctic. The expedition made it clear that dogs cannot compete with vehicles when travelling long distances or hauling profitable payloads. While the average man can quickly adapt himself to driving a tractor in snow, a dog driver and his team need long and constant training and practice to reach a pitch of proficiency. Although the men did extremely well, at no stage could they have reached the standard of skill shown by the professional drivers in a party such as Amundsen's.

But a dog team is a mobile form of transport and can give useful support to a survey or geological party in rough or crevassed country. If the dog teams are airlifted to the area to be explored, and if they are kept supplied by air so that they can travel with reduced loads and so move briskly about, they are probably still the best form of transport for a close examination of the many great mountain ranges and glaciers which fringe the barren wastes of the polar plateau.

RADIOCÆSIUM AND POTASSIUM-40 IN NORWEGIAN-PRODUCED MILK

By K. MADSHUS and J. BAARLI
Norsk Hydro's Institute for Cancer Research, Oslo, Norway

THE radioactive isotopes cæsium-137 and strontium-90 represent a major part of the radiation hazard to man caused by nuclear explosions, by reason of their long half-lives (28 and 27 years, respectively). The rate of fall-out depends to a large extent on the geographical locality, and on the weather conditions at the relevant places of interest[1,2]. There is evidence that the northern hemisphere and places with high rate of precipitation[3] receive the highest fall-out. These conditions obviously hold for Norway.

The degree of hazard which the ionizing radiation represents to man can, in principle, be estimated in two ways. One method is to determine the amounts of the isotopes in foodstuffs, taking into account the discriminating factors involved during passage of the food through the human body. The other method is the direct measurement of radiation from the human body. Milk appears to be one of the main constituents of the human diet carrying the radioactive material from the ground into the human body.

The present work was undertaken to obtain as reliable information as possible about the concentration of cæsium-137 in Norwegian-produced milk. This isotope is most important in view of the genetic effects of its γ-radiation ($E_\gamma = 660$ keV.), compared with the more localized damage caused by the β-radiation from strontium-90 ($E_\beta = 0{\cdot}61$ MeV.).

It seems an established fact[4] that the fall-out ratio strontium-90/cæsium-137 from atom-bomb debris is nearly constant. This is not only the case for soil and rain-water; milk samples collected within the same districts also show the same tendency[5]. As the experimental determination of cæsium-137 is a rapid process compared with the more laborious determination of strontium-90, the content of cæsium-137 can serve as a quick monitor of the rate of strontium-90 fall-out.

The equipment used for studies of low-level γ-radiation has been described elsewhere[6]. It is composed of a heavily shielded scintillation detector, consisting of a sodium iodide (thallium) crystal 2½ in. diameter × 3 in. and a Du Mont 6363 phototube in connexion with an R.C.L. 256-channel pulse-height analyser. A cross-section of the equipment is shown in Fig. 1. The background radiation in the measuring space of this equipment is found to be $212 \pm 1{\cdot}0$ counts/min. in the energy-range 80–1,700 keV. The background, in the two pulse-height regions of special interest to the present study, is $14{\cdot}1 \pm 0{\cdot}1$ counts/min. in the cæsium-137 photopeak range, and $5{\cdot}3 \pm 0{\cdot}1$ counts/min. in the potassium-40 peak. The position of the photopeak in the pulse-height spectrum is stable over a long period, being 0·75 per cent after the initial warm-up. The equipment has been calibrated using dried milk with a known concentration of cæsium-137 and potassium-40. The samples were canned in metallic containers, each holding 250 gm. of dried milk. We are much indebted to Dr. D. V. Booker, of the Atomic Energy Research Establishment, Harwell, for supplying us with several of his measured samples used here for calibration purposes.

Two kinds of standards were used, one containing full-cream dried milk, and the other skimmed dried milk. The calibration samples contained 670 pc./kgm. and 485 pc./kgm. of cæsium-137 (1 pc. = 10^{-12} curie) with a potassium content of 14·9 and 17·6 gm./kgm. for the skimmed milk, and 445 pc. cæsium-137/kgm. and 11·2 gm./kgm. for the full-cream dried milk.

Dried skimmed milk and full-cream dried milk were obtained from a dairy receiving milk from districts in the Tröndelag and Hedmark counties. The former county lies in central Norway, near the coast. It is one of the greatest farming districts in the country. Hedmark lies in south-east Norway, about 300 miles from the west coast.

The individual samples were taken from batches of about 22,000 l. Each sample contained 250 gm. of dried milk, the same as the standard sources used for calibration. The canning was also identical. Measurements of samples were carried out over periods of 4 hr. or more. Background and calibration runs were made from time to time. No significant variations in the number of counts stored in the cæsium-137 and potassium-40 photopeaks, exceeding the statistical errors, were observed. No radioactivity which could be attributed to radio-elements other

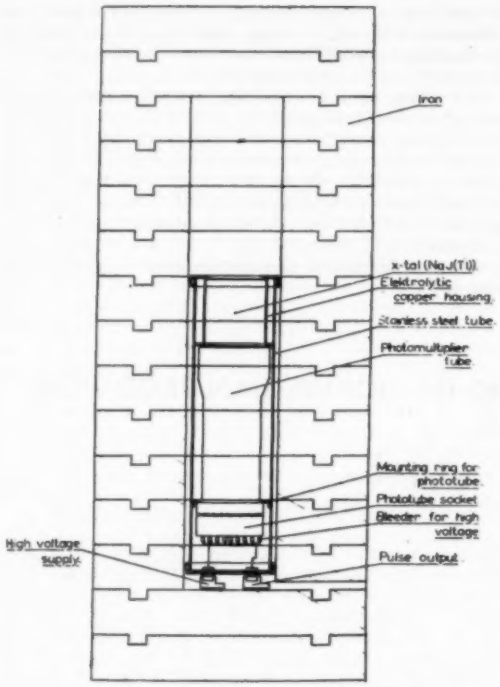

Fig. 1. Scintillation detector and shielding used

than cæsium-137 and potassium-40 was observed in the dry milk measured. In this connexion it must be mentioned that the measurements of the samples from 1958 were all made early in 1959. The other samples were usually measured one month after the date of manufacture.

The results were analysed by counting the observed pulses in the photopeak only, and subtracting the background, correcting for drift of the photopeak region exceeding 0·5 per cent. Because of the scattering of the 1·46 MeV. γ-radiation from potassium-40 and secondarily produced radiation (bremsstrahlung) caused by the β-particles from potassium-40 ($E_\beta = 1{\cdot}4$ MeV.), it was necessary to apply a correction term to the number stored in the cæsium-137 photopeak. This fraction was determined experimentally by observing the extra counts in the cæsium-137-region as a result of an added known amount of potassium-40 mixed into the samples.

With the crystal size and geometry used in the present arrangement, the correction factor has been found to be 22 per cent of the net counts in the potassium-40 photopeak. This value is in close agreement with theoretical calculations based on the resolution obtained for cæsium-137 and potassium-40 (11·0 per cent and 7·0 per cent respectively).

Because of the nature of the radiation process, each measurement carries a statistical error, consisting of the error in the background and sample determination. The results of the measurements are shown in Table 1, together with the experimental errors.

Table 1 shows that the potassium content in the samples amounts to 14–17 gm./kgm. for skimmed dry milk, and 10–12 gm./kgm. for full-cream dried milk. These values are in good agreement with results obtained elsewhere[5,7,8].

The cæsium-137 content during the period January 1958–August 1959 shows the same tendency for both the skimmed and full-cream dried milk from both areas. During the spring of 1958, there is a slow increase in the cæsium-137 content up to June, where an increase of nearly a factor of 2 is recorded. The reason for this sudden jump is primarily in the feeding of the cows with fresh grass. In the autumn, from October 1958, there is a general tendency towards decrease until January 1959, when a value of 310 pc. cæsium-137/kgm. is found in full-cream dried milk from Hedmark, and 650 pc. cæsium-137/kgm. in skimmed milk from Tröndelag. These values are considerably higher than those reported for January 1958. A decrease is further noticed during the spring of 1959, lasting until April. In May the content of cæsium-137 reaches a value of 1,005 pc./kgm. for skimmed milk from Tröndelag. This increase continues, and a value of 1915 pc./kgm. is reached in August 1959. This is the highest level found by us in dried milk.

It is of interest to compare the values of the cæsium-137 content in milk, both with the measured

Table 1. Cæsium-137 in Milk

District	Date of manufacture	(pc.) Cæsium-137 per kgm.	Potassium (gm./kgm.)	(pc.) Cæsium-137/ potassium (gm.)	
Hedmark	13/1/58	140 ± 20	10·6 ± 0·2	13·2	whole milk
,,	5/3/58	125 ± 20	12·3 ± 0·2	10·2	,, ,,
,,	2/4/58	190 ± 20	11·5 ± 0·2	15·5	,, ,,
,,	2/5/58	180 ± 20	11·8 ± 0·2	15·2	,, ,,
,,	2/6/58	245 ± 20	11·3 ± 0·2	21·8	,, ,,
,,	2/7/58	505 ± 20	10·2 ± 0·2	49·5	,, ,,
,,	20/10/58	550 ± 40	11·5 ± 0·4	47·9	,, ,,
,,	3/11/58	430 ± 20	10·8 ± 0·2	39·8	,, ,,
,,	27/11/58	185 ± 20	10·8 ± 0·2	17·1	,, ,,
,,	3/1/59	310 ± 40	11·0 ± 0·4	28·1	,, ,,
,,	8/1/59	310 ± 20	10·7 ± 0·2	29·0	,, ,,
,,	28/2/59	250 ± 20	11·4 ± 0·2	21·9	,, ,,
,,	3/3/59	210 ± 40	11·5 ± 0·4	18·2	,, ,,
Tröndelag	1/2/58	570 ± 15	17·7 ± 0·3	32·1	skimmed milk
,,	2/4/58	440 ± 15	17·4 ± 0·2	25·3	,, ,,
,,	2/5/58	335 ± 15	16·3 ± 0·2	20·5	,, ,,
,,	2/9/58	860 ± 15	15·8 ± 0·3	54·5	,, ,,
,,	1/10/58	910 ± 15	16·4 ± 0·2	55·5	,, ,,
,,	1/12/58	760 ± 15	17·4 ± 0·3	43·7	,, ,,
,,	7/1/59	650 ± 15	18·1 ± 0·3	35·9	,, ,,
,,	5/2/59	650 ± 20	17·3 ± 0·3	37·6	,, ,,
,,	5/3/59	300 ± 15	17·6 ± 0·2	17·1	,, ,,
,,	29/5/59	1,005 ± 20	15·3 ± 0·3	65·3	,, ,,
,,	9/6/59	1,220 ± 20	16·3 ± 0·6	74·7	,, ,,
,,	31/7/59	1,915 ± 40	14·9 ± 0·5	128·8	,, ,,

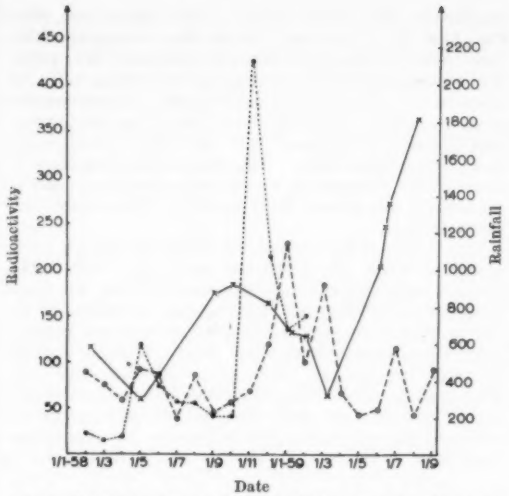

Fig. 2. Total fall-out/month, mm. rainfall/month, and cæsium-137 content (pc./kgm.) in dry milk as a function of time (from Tröndelag). ●...●, total fall-out/month (mc./km.²); ○---○, rainfall/month (mm.); ×——×, cæsium-137/kgm.

values of the total fall-out[9] and the local rainfall. During the summer of 1957, the total fall-out in Tröndelag (Værnes) remained quite constant at 30–35 mc./km.², increasing to 84 mc./km.² in October. These values must be taken into consideration in predicting the content of cæsium-137 in the milk during the winter and spring of 1958, when the cows were fed on hay collected in the summer and autumn of 1957.

The value of the total fall-out is higher in the spring and summer of 1958 than in the preceeding year, ranging up to 119 mc./km.² in April. Fig. 2 shows the total fall-out, the cæsium-137 content in dry milk and the rainfall as a function of time. The seasonal variations in the cæsium-137 content in milk are easily seen from the curves. There is a remarkable increase during spring and summer, and a decrease in the late autumn and winter. There seems to be a slight tendency toward a correlation between the total fall-out and the measured concentration of cæsium-137, the latter lagging by 4–6 months. This correlation is, however, very doubtful, due to the large amount of short-lived fission products in the fall-out.

It is obvious from Table 1 and the curves that the content of cæsium-137 in milk has increased considerably during the past year and a half. It is of special interest to continue these measurements at the present time, when no test explosions have taken place for about a year, in order to establish the maximum level for cæsium-137 in milk and the time required to reach this point.

We are indebted to the Norske Melkefabrikker for the regular supply of milk samples, to the Norwegian Defence Research Establishment for interest and finally to the Norwegian Cancer Society for financial support.

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ALKALINE CONVERSION OF 4-HYDROXYPHENYLPYRUVIC ACID TO 4-HYDROXYBENZALDEHYDE

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DURING recent investigations of the biosynthesis of aromatic compounds by *Escherichia coli* and *Aerobacter aerogenes* (to be published) a compound, compound *C*, was detected in experimental samples by the appearance of an absorption maximum at 325–330 mμ, $pH > 12$. Compound *C* was later recognized as 4-hydroxybenzaldehyde, which absorbs as shown in Fig. 1. It was realized that this compound was largely an artefact resulting from the action of alkali on another compound, compound *D*. Compound *D* was then found to be identical with 4-hydroxyphenylpyruvic acid. It is the aim of this communication to bring to notice the alkaline conversion of 4-hydroxyphenylpyruvic acid to 4-hydroxybenzaldehyde.

A sample of 4-acetoxy-α-acetamido-cinnamic acid was prepared by the method of Saul and Trikojus[1] and recrystallized from ethanol (m.p. 228° C., $C_{13}H_{12}NO_5$ requires: C, 59·3; H, 5·0; N, 5·3; O, 30·4 per cent; found: C, 59·3; H, 5·2; N, 5·5; O, 30·4 per cent). This was hydrolysed as required to 4-hydroxyphenylpyruvic acid using Dowex cation exchange resin 50 − × 8 (hydrogen form) as described by Acerbo, Schubert and Nord[2]. The product, m.p. 215–217° C., gave better crystals when recrystallized from 0·1 *M* hydrochloric acid although the m.p. fell to 212–216°, perhaps because of the presence of tautomeric forms. Paper chromatography indicated the presence of a little 4-hydroxybenzaldehyde. This impurity was consistent with the analytical figures for the recrystallized 4-hydroxyphenylpyruvic acid ($C_9H_8O_4$ requires: C, 60·0; H, 4·45; O, 35·5 per cent; found: C, 60·18; H, 4·69; O, 35·0 per cent). The spectrum of a 10^{-3} *M* solution in 0·1 *M* phosphate buffer, *p*H 7·7 (Fig. 2) closely approximated to the spectrum of the keto form of 4-hydroxyphenylpyruvic acid in aqueous solution given by Knox and Pitt[3]. $E_{276\,m\mu} = 2{\cdot}1 \times 10^3$ was

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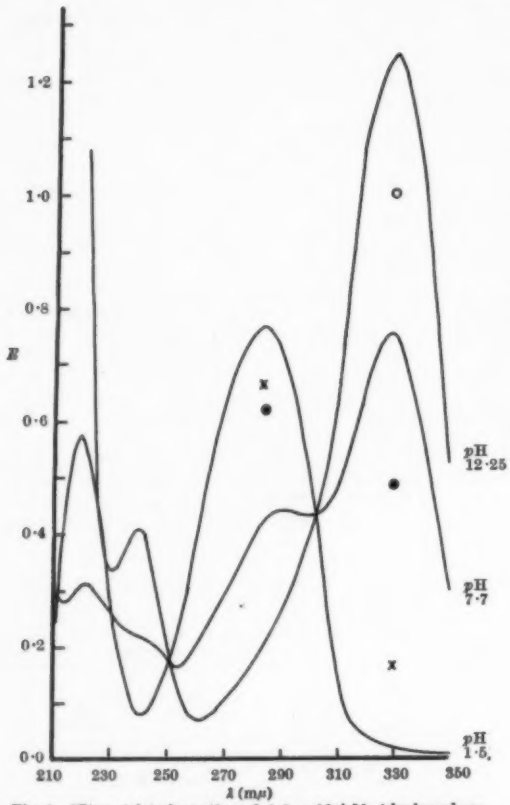


Fig. 1. Ultra-violet absorption of $0{\cdot}5 \times 10^{-4}$ *M* 4-hydroxybenzaldehyde. Original solution in 0·1 *M* phosphate buffer, *p*H 7·7. Samples were adjusted with 10 *N* sodium hydroxide or 10 *N* hydrochloric acid to the desired *p*H. Absorption at *p*H 12·25 is attributed to 100 per cent phenate ion (constant above approx. *p*H 9) and at *p*H 1·5 to 100 per cent undissociated phenol (constant below approx. *p*H 6·0). ○, *p*H 8·0; ●, *p*H 7·45; ×, *p*H 6·9

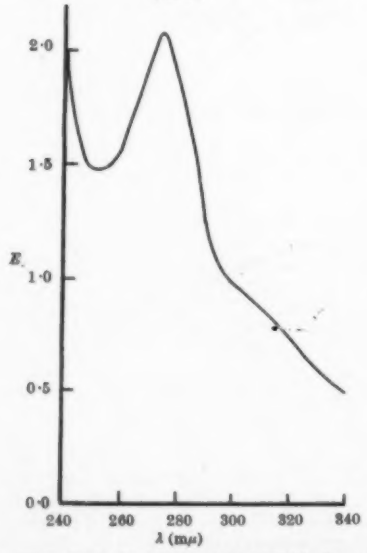


Fig. 2. Ultra-violet absorption of 10^{-3} *M* 4-hydroxyphenylpyruvic acid in 0·1 *M* phosphate buffer, *p*H 7·7

similar to the value $2{\cdot}27 \times 10^3$, calculated from Fig. 2 of these authors. With the exception of the case cited below, further purification by paper chromatography did not affect the changes to be described. Ultra-violet absorption measurements were recorded manually from short to long wavelength using a Unicam *SP* 500 spectrophotometer and 1-cm. silica cells. Because of the rapidity of some of the changes it would be preferable to use an automatic recording instrument if this work was extended.

Fig. 3 shows the irreversible spectral change which occurred when the *p*H was raised to >12. This change was almost instantaneous even at room temperature (20–25°). Subsequent variation of the *p*H produced changes of adsorption characteristic of 4-hydroxybenzaldehyde (cf. Fig. 1) with definite isobestic points at 300 mμ and 250–255 mμ. The absorption maximum at 330 mμ was attributed to the phenate ion and that at 280–285 mμ to the undissociated phenol. The *pK* value for this ionization was calculated from the absorption data as

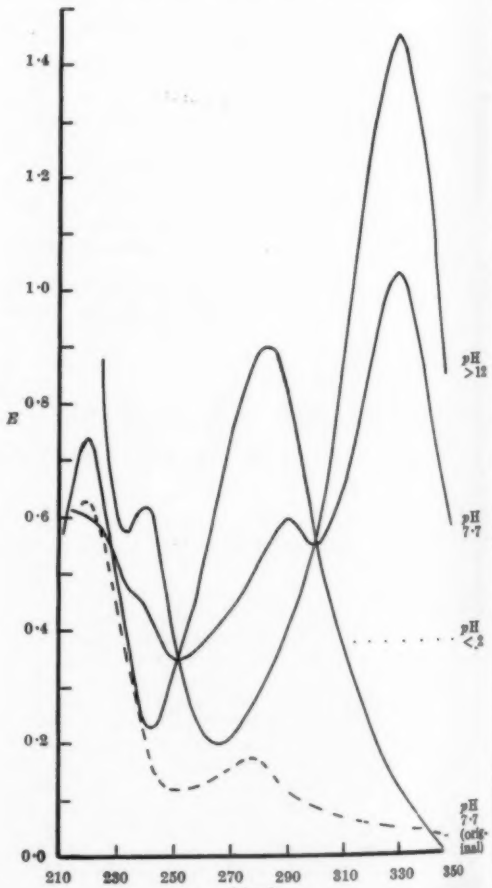
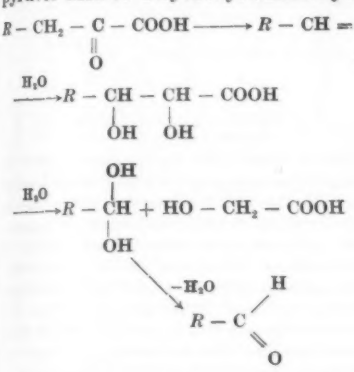


Fig. 3. The conversion of 4-hydroxyphenylpyruvic acid to 4-hydroxybenzaldehyde. Ultra-violet absorption of approx. $0{\cdot}6 \times 10^{-4}$ *M* 4-hydroxyphenylpyruvic acid in 0·1 *M* phosphate buffer *p*H 7·7. The *p*H was adjusted to >12 with alkali and the spectrum recorded immediately; *p*H was afterwards adjusted to <2 and then 7·7 (cf. original curve at *p*H 7·7). $E_{max.}$ 240 mμ tends to be lost on storage as found with 4-hydroxybenzaldehyde

7·68 ± 0·08 which was in agreement with the value 7·66 calculated from the literature[4].

The following mechanism is tentatively proposed for the alkaline conversion of 4-hydroxyphenylpyruvic acid to 4-hydroxybenzaldehyde.



Support for an intermediate chromophorically similar to tyrosine was obtained following paper chromatography of 4-hydroxyphenylpyruvic acid in water/ethylmethylketone/diethylamine (77 : 921 : 2)[5] and elution with phosphate buffer, *p*H 7·7. This treatment for some unknown reason slowed down the effect of subsequent alkali, and thus allowed the detection of transient maxima at 240 mμ and 290–295 mμ similar to the absorption of tyrosine at *p*H > 12 (Fig. 4).

It seemed possible that the alkali-induced replacement of a pyruvic acid side-chain by an aldehyde group was a more general reaction. Phenylpyruvic acid eluted from paper chromatograms and treated with alkali (*p*H > 12), first developed an absorption maximum at 320 mμ, which then declined in intensity to an insignificant level. Subsequent adjustment to *p*H < 2 did not result in the changes characteristic of phenylpyruvic acid. In general, the spectral changes seemed consistent with a slow conversion to benzaldehyde, but this was not investigated further. Kaper and Veldstra[6] reported that chromatography of indolepyruvic acid in alkaline solvents gave indolealdehyde as one product of breakdown. It would therefore appear that in the general handling and chromatography of pyruvic acid derivatives of these types, it is as well to avoid high *p*H particularly since the conversion of 4-hydroxyphenylpyruvic acid to 4-hydroxybenzaldehyde was apparent even at *p*H 10·0.

In lignin chemistry oxidation with nitrobenzene in alkali was introduced[7] as a degradative procedure by

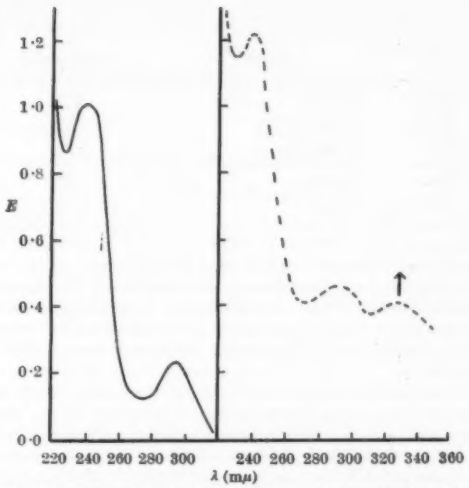


Fig. 4. The absorption at a transient stage in the alkaline conversion of 4-hydroxyphenylpyruvic acid to 4-hydroxybenzaldehyde compared with the spectrum of DL-tyrosine, *p*H > 12 (see text). —, Approx. 10^{-4} *M* DL-tyrosine

which various aromatic aldehydes were liberated, presumably from the lignin. The origin of one of these aldehydes, 4-hydroxybenzaldehyde, gave some concern, and it has been shown[8,9] that protein tyrosine may account for most of this compound released by the nitrobenzene oxidation of buckwheat. Since 4-hydroxyphenylpyruvic acid is considered to be a lignin precursor in grasses[9], the release of 4-hydroxybenzaldehyde from the former using alkali alone may be of particular interest.

This work was supported by a grant from the Australian National Health and Medical Research Council. The analyses were carried out by the Australian Microanalytical Service, Commonwealth Scientific and Industrial Research Organization, Melbourne.

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GLUCOSE-6-PHOSPHATE DEHYDROGENASE DEFICIENCY IN RED BLOOD CELLS OF EAST AFRICANS

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MANY investigations, reviewed by Beutler[1], have shown that about 11 per cent of American Negro males have an intrinsic red blood cell abnormality. A striking feature of the abnormality—and perhaps the primary genetically controlled defect—is low activity of the enzyme glucose-6-phosphate dehydrogenase, which is responsible for the first and rate-controlling step in the hexose monophosphate shunt metabolic pathway in red cells[2]. The defect appears to be inherited as a sex-linked character with full expression in hemizygous males and homozygous females and partial expression in heterozygous

Table 1

Tribe	Locality	Males tested	Enzyme deficiency	Females tested	Enzyme deficiency	Hemizygote = gene frequency
Giriama	Malindi	101	17	65	10	16·8
Bondei	Muheza	121	33	124	24	27·3
Sambaa	Tanga district	29	6	33	5	20·7
Digo	Tanga district	26	6	33	6	23·1
Zigua	Tanga district	26	6	29	4	23·1
Kikuyu	Nairobi and Naivasha district	70	2	73	2	2·9
Masai	Kajiado	59	1	12	0	1·7
Luo	Nairobi and Kisumu district	50	14	27	4	28·0
Ganda	Kampala	40	6	46	5	15·0

females[2]. Persons with the defect are liable to develop severe hæmolysis on exposure to therapeutic doses of the antimalarial 8-aminoquinolines (primaquine, pamaquine, etc.) and certain other drugs, and also on ingestion of broad beans (*Vicia faba*).

The trait is known to be common in many Mediterranean populations, including Sephardic Jews, and also in many South-East Asian populations[1,4]. The only published indications of its presence among continental Africans are isolated reports of hæmolysis induced by pamaquine in a South African, a Nyasaland and an East African Bantu[5,6]. The development of a relatively simple screening test for red cell glucose-6-phosphate dehydrogenase deficiency[4] has made more extensive surveys of the distribution of the trait possible. This report embodies the results of tests on 964 East Africans belonging to 9 different tribes. The test was used as described[4] except that all volumes were reduced to one-half and incubations were carried out in 1-cm. diameter tubes.

The results of the tests are shown in Table 1. Hæmolysates from Western European subjects incubated in the presence of substrate and coenzyme decolorize brilliant cresyl blue in less than 120 min. Hæmolysates from male Africans show a clear bimodal distribution of decoloration times, with the antimode at about 120 min. Spectrophotometric analysis of glucose-6-phosphate dehydrogenase activity[7] in some of the subjects showing decoloration times of longer than 120 min. confirmed that they had significantly lower enzyme activities than normal subjects, and they were therefore classified as hemizygous for the enzyme-deficiency trait. Female Africans show a much less clear distinction between normal and abnormal groups, but those with decoloration times greater than 120 min. were assumed to be heterozygous or homozygous for the enzyme-deficiency trait. Limited family data were consistent with this assumption. The frequency of the abnormal gene, q, equals the frequency of hemizygotes in the male population. The expected frequency of heterozygotes and homozygotes in the female population is $2q(1-q)+q^2$, and the proportion of females showing detectable enzyme deficiency was 41 per cent of that expected, other heterozygotes presumably falling within the normal range of variability in the tests.

The results summarized in Table 1 show that the trait is common in East Africans. However, the distribution is far from uniform. High frequencies of the trait (15–28 per cent) are found among tribes living near the coast and around Lake Victoria, and low frequencies (1·7–2·9 per cent) in the intermediate highland country. The distribution of the trait approximately parallels that of the sickle-cell trait in the same region[8]. All other populations known to have high frequencies of the enzyme-deficiency trait[4] live in regions where malaria is, or was until recently, endemic. Thus the local distribution of the trait in East Africa and the overall distribution are consistent with the interpretation that subjects with deficient glucose-6-phosphate-dehydrogenase activities in red cells are at a selective advantage in malarious environments. There are, in fact, metabolic reasons why malaria parasites might not multiply as well in enzyme-deficient cells as in normal red cells[4]. Recently, evidence has been obtained[9] that young malaria-susceptible East African children of both sexes from a region where *P. falciparum* is holoendemic show lower parasite-counts when enzyme deficient than when red cell enzyme activities are normal.

These results suggest that the trait may be maintained as a sex-linked polymorphism by a balance of selective forces. The hemizygote, and to some extent also the abnormal homozygote and heterozygote, are favoured through protection against malaria, and possibly in other ways. On the other hand, the hemizygote, and perhaps also the abnormal homozygote and in exceptional circumstances the heterozygote, may be at a disadvantage owing to their susceptibility to hæmolysis. The broad bean is not normally eaten by East Africans, and why persons with enzyme deficiency are at a disadvantage there is unknown. If there were no disadvantage, the gene might be expected to have become more common, instead of remaining at the same order of frequency among tribes supposed to have different ethnic origins (for example, the Nilo-Hamitic Luo and the Eastern Bantu Bondei). There is disagreement among theoretical geneticists whether a stable polymorphism at a sex-linked locus can be maintained by advantage of the hemizygote alone or whether the heterozygote must be favoured[10]. The finding that enzyme-deficient female as well as male children have lower malaria parasite counts than children with normal red cell enzymes means that both processes could apply in this particular case.

This investigation was supported by a grant from the Colonial Development and Welfare Fund received at the instance of the Colonial Medical Research Committee. I am indebted for hospitality and help to many East African workers, in particulars Drs. D. B. Wilson and D. F. Clyde, Amani; H. Foy, Nairobi and S. Buck, Kampala.

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A NEW COPPER PROTEIN FROM *CHLORELLA ELLIPSOIDEA*

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THE significance of copper in the metabolism of *Chlorella* was first described in 1939 by Green, McCarthy and King[1], who investigated the inhibitory effect of copper-chelating agents on respiration and photosynthesis in *Chlorella pyrenoidosa*. Their findings, that carbon dioxide uptake by *Chlorella* was markedly inhibited in the presence of copper-specific inhibitors in concentrations which were apparently without effect on the respiratory activity of the organism, and readily reversed on the removal of the poison by dialysing the cell suspension against water, indicated the participation of copper in the photosynthesis of *Chlorella*. However, there has been no positive effort to elucidate the function and properties of the copper compound in question. In a series of studies carried out in this laboratory to investigate the oxidation-reduction system in algae, a copper protein complex possessing the capacity to undergo a reversible oxidation-reduction reaction was isolated from *Chlorella ellipsoidea*. A similar substance was also found in the chloroplasts of higher plants. This article will briefly describe the isolation and purification as well as several properties of the copper protein obtained from *Chlorella ellipsoidea*.

The copper protein was readily extracted by disrupting the algal cells for 30 min. in a sonic oscillator (20 kc./s.) with the addition of about a half weight of alumina, or by soaking the lyophilized cells or acetone powder of *Chlorella* in a sufficient amount of dilute phosphate buffer of neutral *p*H. The typical procedure for extraction and purification of the substance is as follows: 1 kgm. of lyophilysed cells of *Chlorella ellipsoidea* was suspended in 8·0 l. of 0·01 *M* phosphate buffer (*p*H 7·0), and left at 10° C. for 16 hr. with several stirrings. The algal cells were removed by centrifugation at 3,000*g* for 20 min., and 300 gm. of ammonium sulphate was added with stirring to 1·0 l. of the supernatant. The precipitate formed was removed by centrifugation at 3,000*g* for 30 min. and the supernatant was saturated with ammonium sulphate and left at room temperature for 1 hr. The precipitate formed was collected by centrifugation, dissolved in a small amount of water and dialysed for 24 hr. against 0·02 *M* phosphate buffer, *p*H 7·0. Further purification of the substance was carried out by column chromatography, using diethylaminoethyl-cellulose as adsorbent. The substance dialysed was charged on a column (3 cm. in diameter and 10 cm. in height) packed with the adsorbent buffered with 0·02 *M* phosphate buffer, *p*H 7·0. The charged column was thoroughly washed with a sufficient amount of 0·05 *M* phosphate buffer *p*H 7·0, and the substance was eluted with 0·2 *M* phosphate buffer, *p*H 7·0.

The eluate thus obtained showed a bright yellow colour and, on addition of ferricyanide, its colour changed to green, indicating the oxidation of the copper protein which had been in the reduced form. The values for the degree of purity of the eluate as the ratio of extinction at 278 mμ (maximum of protein peak) to that at 597 mμ (maximum of peak in visible region, see below), was found to be 4·8. The oxidized substance, if not so highly purified, was generally found to undergo a gradual auto-reduction without any addition of reducing agents, and even after thorough dialysis against water. The substance was therefore subjected to subsequent chromatography in the reduced form to prevent the broadening of the elution pattern. The copper protein, dialysed and reduced with ascorbic acid, was again charged on a column of diethylaminoethyl-cellulose equilibrated with 0·02 *M* phosphate buffer, *p*H 7·0 (2 × 20 cm.). The column was washed with 0·05 *M* and 0·1 *M* of phosphate buffer (*p*H 7·0) and the substance was then eluted with 0·2 *M* of phosphate buffer, *p*H 7·0. This procedure was repeated until no yellow colour was observed in the eluate. The water-clear solution thus obtained had a purity index (see above) of 2·6 and showed the deep-blue colour of oxidized copper protein on the addition of ferricyanide. It was found that the oxidized substance, in this stage of purification, was no longer auto-reducible. The last manipulation of column chromatography was therefore carried out with the oxidized substance. In this case, the charged column was washed with 0·03 *M* phosphate buffer, *p*H 7·0, and the substance was eluted with 0·1 *M* of phosphate buffer, *p*H 7·0. The value finally obtained for the purity index was 1·63.

Fig. 1 shows the absorption spectra of the oxidized and reduced form of the substance. In the oxidized form, a sharp absorption peak due to the protein has a maximum at 278 mμ and a slight shoulder at 284 mμ. In the visible region, there is a broad absorption peak ranging from 500 mμ to 700 mμ and possessing a maximum at 597 mμ. In the reduced form, no absorption was observed in this region. The blue colour of the oxidized substance was found to disappear on addition of sodium diethyl-dithiocarbamate or on dialysing against salicylaldoxime or cyanide solution; this reappeared, although not completely, on dialysis for 24 hr. against a copper sulphate

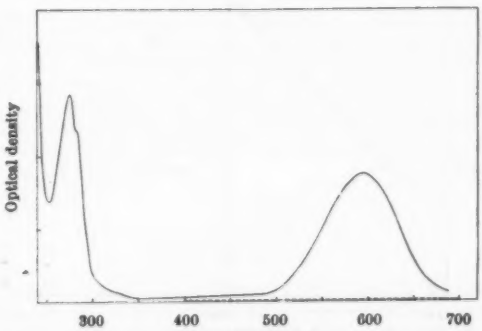

Fig. 1. Absorption spectra of copper protein from *Chlorella ellipsoidea*. Solid line, oxidized form; broken line, reduced form (reduced with ascorbic acid)

solution of 10^{-3} *M*. A spectrophotometric experiment revealed that the blue colour which reappeared was due to an absorption peak identical with that of the untreated preparation. It is inferred from these findings that the characteristic peak in the visible region is due to copper in the form of a complex with protein.

The oxidation-reduction potential of the substance is determined, using a ferri- and ferro-cyanide mixture as oxidation-reduction buffer. In Fig. 2, the values for log (ferrocyanide/ferricyanide) are plotted against those for log (reduced copper protein/oxidized copper protein). The slope of the curve indicates a one-electron change in the oxidation and reduction of the copper protein. From these results, the normal potential of the copper protein is calculated to be 390 mV. at 20° C. and *p*H 7·0.

The reduced form of the purified copper protein was found to be non-auto-oxidizable. The oxidized substance was reduced with ascorbic acid, hydroquinone and other ordinary reducing agents. It was found that the copper protein was instantaneously reduced by reduced mammalian cytochrome *c* and *Chlorella ellipsoidea* cytochrome 550, which was isolated and purified from *Chlorella ellipsoidea* (details will be published elsewhere). Since cytochrome *f* of *Chlorella* has not been successfully isolated, the reactivity of the copper protein was tested also, with positive results, with another algal cytochrome of high oxidation-reduction potential, *Porphyra tenera* cytochrome 553[2].

A rapid reduction of the oxidized copper protein with reduced pyridine nucleotide as electron-donor was found to be catalysed by the presence of the cell-free extract of *Chlorella*. This reductase was partially purified by fractional precipitation with ammonium sulphate and column chromatography, using diethyl-

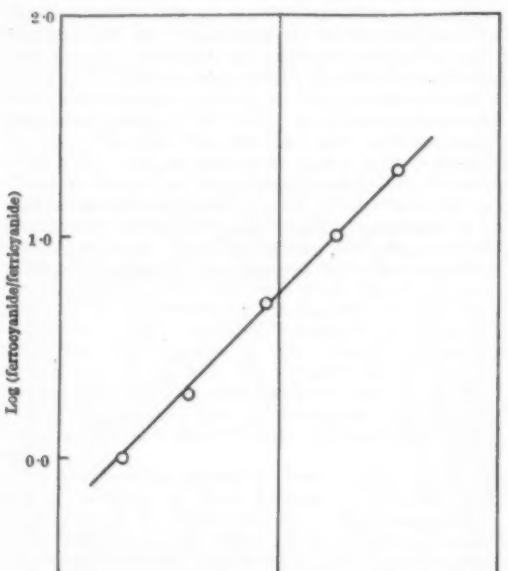

Fig. 2. Oxidation-reduction potential of copper protein from *Chlorella ellipsoidea*. The points refer to the degree of oxidation of copper protein of *Chlorella ellipsoidea* in the presence of varied ratios of ferrocyanide versus ferricyanide in the reaction mixture

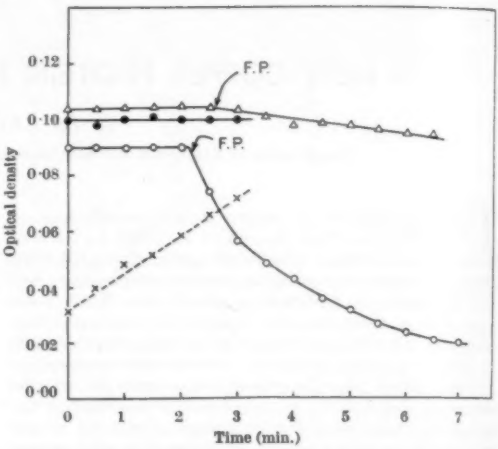

Fig. 3. Reduction of copper protein (and mammalian cytochrome *c*) with reduced pyridine nucleotide as catalysed by *Chlorella* flavoprotein. Reaction mixture, 1·0 ml. of 0·5 *M* phosphate buffer (*p*H 7·0), 0·5 ml. copper protein or horse heart muscle cytochrome *c*, 0·1 ml. reduced pyridine nucleotide, 0·05 ml. flavoprotein and deionized water in 3·0 ml. The reaction was followed spectrophotometrically at 596 mμ and 550 mμ for the reduction of copper protein and cytochrome *c*, respectively. ○, △, reduction of copper protein with reduced triphosphopyridine nucleotide and reduced diphosphopyridine nucleotide, respectively. Flavoprotein was added at the time marked *F.P.* ●, absorption in the presence of copper protein and flavoprotein alone (that is, without addition of reduced pyridine nucleotide); ×, reduction of cytochrome *c* with reduced triphosphopyridine nucleotide. Flavoprotein was added as catalyst at time zero

aminoethyl-cellulose as adsorbent. (The preparation thus obtained showed a yellow colour, which disappeared on reduction with sodium hydrosulphite. The absorption spectrum of this substance in the oxidized form showed three peaks with absorption maxima at 275, 380 and 465 mμ suggesting the flavoprotein nature of the enzyme.) As will be seen in Fig. 3, this enzyme catalyses the reduction of the oxidized copper protein with reduced pyridine nucleotide as electron donor. The rate of this reaction was markedly faster with reduced triphosphopyridine nucleotide than with reduced diphosphopyridine nucleotide. It was also found that this preparation had the capacity to catalyse the reduction of oxidized mammalian cytochrome *c* with reduced triphosphopyridine nucleotide (Fig. 3). It is impossible to compare the activity of this enzyme toward the copper protein with that toward cytochrome until the molar extinction coefficient of the former is estimated.

A substance with similar spectrophotometric and electro-chemical properties has been extracted from chloroplasts of spinach by K. Takamatsu (personal communication) in this laboratory. It has also been discovered by me in the chloroplasts of *Chrysanthemum coronarium*. The wide distribution of this substance in various photosynthetic organisms suggests that it is playing some part in the photosynthesis of these organisms. Further investigations to elucidate the physiological function of this substance are in progress.

I wish to thank Prof. A. Takamiya for his valuable advice and encouragement in this work. Lyophilized algal cells were kindly provided from the Tokugawa Biological Institute.

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LETTERS TO THE EDITORS

MATHEMATICS

Gravitational Waves in General Relativity

THE emission of gravitational waves from a finite isolated axially symmetrical material system in otherwise empty space has been investigated by consideration of the metric :

$$ds^2 = \left(\frac{V}{r}e^{2\beta} - r^2e^{2\gamma}U^2\right)du^2 + 2e^{2\beta}dudr +$$

$$2r^2Ue^{2\gamma}dud\theta - r^2\,(e^{2\gamma}d\theta^2 + \sin^2\theta\, e^{-2\gamma}d\varphi^2)$$

Einstein vacuum field equations have been solved by an expansion in negative powers of r which represents radial distance in a well-defined sense. In this expansion it has been assumed that only outgoing waves are present. The expression :

$$\tfrac{1}{4}\lim_{r\to\infty}\int_0^{\pi}(r-V)\sin\theta d\theta$$

represents mass in the static case, and forms a suitable generalization of this static concept to the dynamical case.

The following results have been found :

(1) If a system is static before some instant, then undergoes motion, and eventually again returns to a static state, then its mass in the final state is less than its mass in the initial state.

(2) There exists a class of possible motions of the source in which the curvature tensor (measured by its physical components) falls off like r^{-3}. In this case no radiation is sent out and no loss of mass occurs. The existence of such a class of motions is related to Infeld's[1] result that a set of freely moving particles does not radiate. This case differs from the stationary one by, among other characteristics, $\lim (r-V)$ being a function of θ though not of u.

(3) There exists a class of motions of the source in which the curvature tensor falls off like r^{-2}. In this case the power received by a set of small receivers covering a large sphere surrounding the source tends to zero as the radius of the sphere tends to infinity, since small receivers absorb energy at a rate proportional to the square of the curvature tensor. Nevertheless the source loses mass, because at any distance from the source a suitably constructed large receiver could absorb a finite amount of energy.

(4) For general motions the curvature tensor falls off like r^{-1}, but, because of (2), there is no close relation between the mass loss of the source and the energy that could be absorbed by distant small receivers. This point underlines the non-localizable nature of gravitational energy.

I am much indebted to Dr. F. A. E. Pirani for innumerable discussions that have done much to improve my understanding of the problem.

Full details of the work (carried on partly in collaboration with Dr. M. G. J. van der Berg, Department of Applied Mathematics, University of Liverpool) will be published elsewhere.

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PHYSICS

Time-Dependent Tensile Strength of Solids

DURING the course of studying the strain-rate effects of a number of irradiated and non-irradiated polymeric solids as well as some metallic solids (refs. 1 and 2 and unpublished results) a common relationship between stress and strain-rate has been observed. For any given value of strain the stress obtained at different rates of straining is linearly related with the logarithm of the strain-rate. Mathematically, if ε is the total given strain at any given temperature T, then the stress σ is related with the strain-rate $\dot{\varepsilon}$ in the following manner :

$$\dot{\varepsilon} = \dot{\varepsilon}_0 e^{\left.\frac{\sigma-\sigma_0}{m}\right|_{\varepsilon}} \qquad (1)$$

where $\dot{\varepsilon}_0$ and σ_0 are constants independent of the strain ε, and m, which is also independent of the strain, is the slope of the straight line when the log of strain-rate is plotted against the stress. Or in another form, when the rate of straining is constant :

$$t = \frac{\varepsilon}{\dot{\varepsilon}_0}e^{\left.\frac{\sigma_0-\sigma}{m}\right|_{\dot{\varepsilon}}} \qquad (2)$$

Depending upon the value of ε, which is a measure of molecular configuration of the solid in terms of deformation[3], the time-dependent strength can be evaluated.

As one special case, if we let :

$$\dot{\varepsilon} = \dot{\varepsilon}_b = \frac{\varepsilon_b}{t_b}$$

then from (1) :

$$t_b = \frac{\varepsilon_b}{\dot{\varepsilon}_0}e^{\frac{\sigma_0-\sigma_b}{m}} \qquad (3)$$

where t_b is the time to fracture, ε_b is the fracture strain and σ_b the stress maintained until fracture occurs. This agrees well with the current theoretical and experimental developments of the subject[4-8].

On the basis of considering the oscillation and breaking of atomic bonds, the time-dependent strength properties of solids has been reported and may be expressed as follows[4] :

$$t_b = \frac{1}{\omega}e^{\frac{E-2\cdot\delta\frac{\sigma}{n}\sigma_b}{kT}} \qquad (4)$$

where t_b is the time taken for the sample to break under the tensile stress σ_b, ω corresponds to some bond oscillation frequency, n is the number of bonds per unit area the normal of which is in parallel to these bonds, E is the bond energy, 2δ is approximately the distance the bond will stretch before

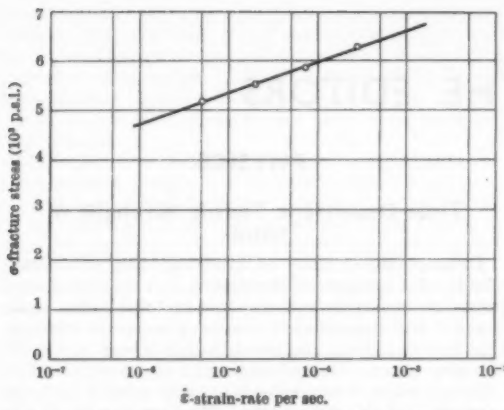

Fig. 1. Effect of strain-rate on breaking stress of polystyrene solid

breaking, k is the Boltzmann constant, and T is the absolute temperature.

According to another theoretical analysis based on the theory of absolute reaction-rates for simple tension[6], the time taken to fracture is related to a constant fracture stress σ_b of a solid body in the following manner:

$$\log t_b = A - B\,\sigma_b \qquad (5)$$

where t_b is the time to fracture and A and B are constants.

Experimentally similar results have been obtained[7,8] for various solids. Hsiao and Sauer[7] have reported this linear relationship between breaking stress and logarithm of time for solid polystyrene at room temperature. Zhurkov and his colleagues[8] have made a systematic study of not only time- but also temperature-dependent fracture phenomena for a large number of various solids. The time t_b taken for a solid to fracture under a constant stress σ_b was found to obey a general law that:

$$t_b = t_0 e^{\frac{U_0 - \gamma\sigma_b}{kT}} \qquad (6)$$

where t_0, U_0 and γ are constants which define the strength properties of the solid. It is interesting that the quantity U_0 was found to coincide in magnitude with the binding energy of atoms in the crystal lattice of metals and alloys. The quantity t_0 was found to be constant for all the metals investigated and of the same order of magnitude as the period of vibration of atoms in the crystal lattice. A very close resemblance between (6) and (3) is quite evident.

As another special case in the creep process the total strain-rate is equal to the creep-rate, that is, $\dot{\varepsilon} = \dot{\varepsilon}_c$ and $\dot{\varepsilon}_0 = \dot{\varepsilon}_{0c}$, where ε_c and ε_{0c} are creep strains. Using these relations, if σ_c is the creep stress, then (1) can be reduced to the following form:

$$\dot{\varepsilon}_c = \dot{\varepsilon}_{0c}\, e^{-\frac{\sigma_0 - \sigma_c}{m\sigma_0}} \qquad (7)$$

indicating that the plots of $\log t_b - \sigma_b$ from (3) and $\log \dot{\varepsilon}_c - \sigma_c$ from (7) have equal but opposite slopes. This is well illustrated by Zhurkov's excellent experimental work for metals and alloys[8].

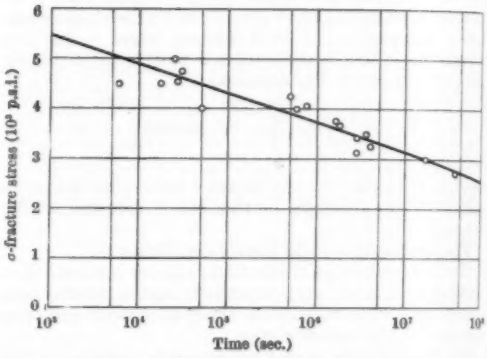

Fig. 3. Effect of time on fracture stress of polystyrene solid

Quite recently, Zhurkov and Sanfirova[9] have obtained the relation between the strength and the constant creep-rate of metals and alloys. They found that:

$$\dot{\varepsilon}_c = \varepsilon_{0c}\, e^{-\frac{Q_0 - \gamma_1\sigma}{kT}} \qquad (8)$$

where $\dot{\varepsilon}_c$ is the creep-rate and $\dot{\varepsilon}_{0c}$, Q_0 and γ_1 are constants. They further determined that $Q_0 = U_0$ and $\gamma_1 = \gamma$ for a number of metallic solids. They also claimed that U_0 is dependent on stress, in contrast with the result by Dorn and his co-workers[10] that the activation energy is independent of the stress. But Basinski[11] and others have found that the activation energy is stress-dependent. According to the present analysis the activation energy is not only dependent on stress but also on strain.

However, in order to consider the possibilities of having different mechanisms of creep deformation for different types of solids, it is desirable to use m as the variable parameter.

For metals and alloys, m has one value which reflects one type of mechanism of deformation associated with various dislocations. But for polymer solids m has another value which reflects a different type of deformation mechanism. To give an actual example, consider the time-dependent mechanical properties of solid polystyrene. The effect of log of strain-rate on the fracture stress is shown in Fig. 1. The plot of the log of creep-rate against the creep stress is given in Fig. 2. The slopes of the two curves are evidently not the same. Com-

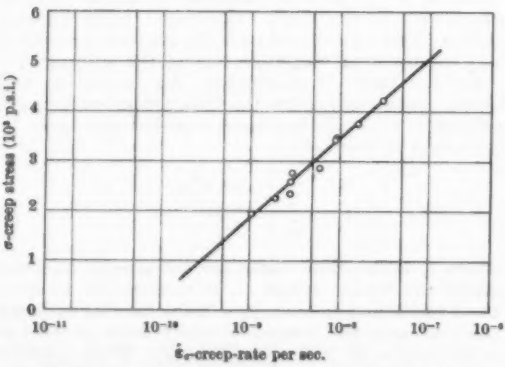

Fig. 2. Creep stress and creep-rates of polystyrene solid

paring with the curve plotted in Fig. 3, the log of time against fracture stress, it is seen that the slope of this curve is equal but opposite to that of the curve in Fig. 1.

In conclusion, it seems reasonably safe to consider that in describing the time-dependent tensile strength properties of a large number of solids there exists a basic linear law between the logarithm of strain-rate $\dot{\epsilon}$ and the applied tensile stress σ :

$$\dot{\epsilon} = \dot{\epsilon}_0 e^{\frac{\sigma - \sigma_0}{mT}} \Big|_{\epsilon}$$

where $\dot{\epsilon}_0$ and σ_0 are constants and m is a material constant proportional to the absolute temperature T.

This work was supported in part by the U.S. Atomic Energy Commission.

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Size Distribution of Tobacco Smoke Droplets by a Replica Method

Hitherto it appears that when size distributions of tobacco smoke droplets have been made by light or electron microscopy, the droplets have been caught on glass surfaces or one of the usual kinds of specimen support film, and upon deposition they have spread on the sampling surface (Fig. 1*a* and *c*). As a result, published size distributions obtained by these methods have been of the spread diameter of the droplets instead of their true diameter as they existed in the smoke at the time of sampling.

A replica method for determining the size distribution of non-volatile droplets by electron microscopy[1] makes it possible to relate the diameters of lens impressions, formed by spread-out droplets sampled on a wet gelatine film, to the diameter of the droplets themselves. This method has now been applied successfully to the determination of the size distribution of tobacco smoke droplets.

Comparative size distributions of cigarette smoke droplets have been made on samples obtained simultaneously on collodion support films by means of the thermal precipitator (Fig. 1*a*) and an electrostatic precipitator, and on wet gelatine film by means of the electrostatic precipitator followed by the replica method (Fig. 1*b*). The electrostatic precipitator was of the parallel-plate type with an electrode separation of 1 cm. and employing a potential difference of 5 kV. Droplets from the smoke of an artificially smoked cigarette without filter tip and a normally smoked cigarette also without filter tip have been examined. The artificial smoking was carried out by inserting the lighted cigarette in the inlet of a 1-litre glass sampling cylinder and drawing smoke through by means of a hand sampling pump at the rate of 35 ml./2 sec. To obtain the normally smoked cigarette cloud, the smoker drew smoke into the mouth and filled the sampling cylinder by gently blowing the smoke into it. In both cases the smoke was approximately 10 sec. old when sampling was commenced, and the concentration was such that a satisfactory thermal precipitator sample was obtained in 2 sec. and the electrostatic precipitator samples in 10 sec.

The size distribution of droplets in artificially produced cigarette smoke obtained by the three methods of sampling is shown in Fig. 2. Diameters shown are for the spread droplets and the number median diameters are 2·1μ for the thermal precipitator sample, 2·4μ for the electrostatic precipitator sample on collodion film and 0·38μ for the gelatine replica. Only in the case of the replica sample can these values be related to actual droplet diameters. The spread factor[1] (droplet diameter/replica diameter) for tobacco smoke droplets on gelatine was found to be 0·435, so that the median droplet diameter was actually 0·16μ and the maximum droplet diameter 0·54μ. For droplets in the smoke from a normally smoked cigarette the median values were 1·05μ for the thermal precipitator sample, 1·3μ for the electro-

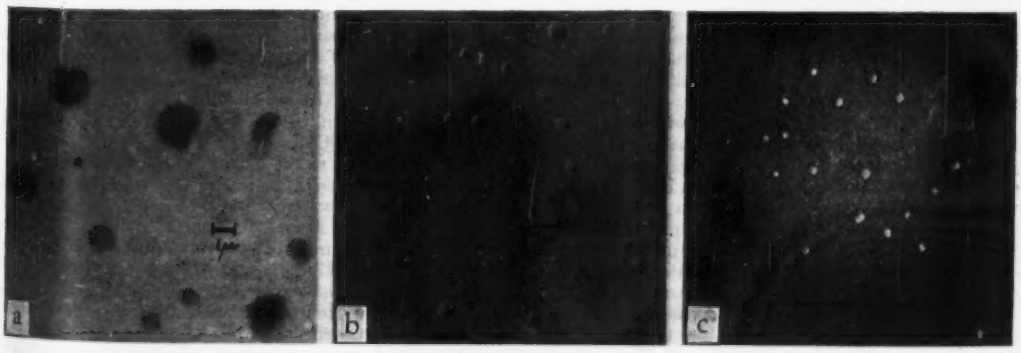

Fig. 1. Electron micrographs of tobacco smoke droplets: (*a*) spread droplets on collodion; (*b*) carbon replica of lens impressions formed by droplets sampled on wet gelatine film; (*c*) spread droplet containing crystals

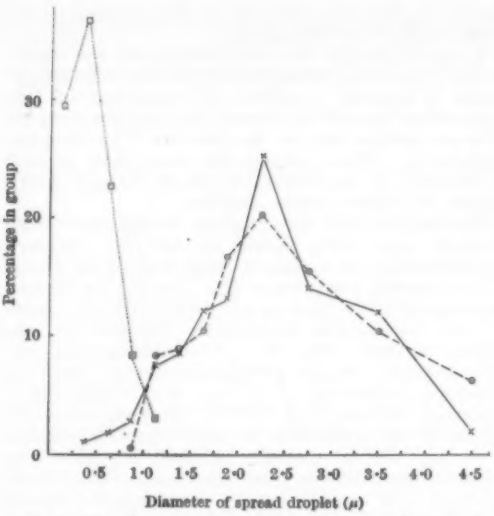

Fig. 2. Size distribution of spread droplets in smoke from an artificially smoked cigarette without filter tip. ×—×, Thermal precipitator and collodion film; ⊙ – – – ⊙, electrostatic precipitator and collodion film; □ · · · □, electrostatic precipitator and gelatine film (replica method)

static precipitator sample on collodion film and 0·46μ for the gelatine replica with a true droplet median diameter of 0·2μ.

It is interesting to compare these values with those obtained by other workers. Langer and Fisher[2], sampling on glass and sizing by dark-field microscopy, obtained values for the diameters of 0·6μ (median) and 1·6μ (maximum). For a smoke of similar age, Harris and Kay[3], sampling on 'Formvar' film and sizing by electron microscopy, appear to have obtained a maximum droplet diameter of approximately 5μ, which is the largest size for samples taken on collodion in the present investigation. DallaValle[4], by means of electrostatic separation studies, found a size range of 0·1–0·25μ, and Sinclair[5], using a light-scattering method, a size range up to 0·5μ diameter. It is evident that spreading of the droplets always occurs when they are deposited upon a sampling surface and, unless the spread diameter can be related to the original droplet diameter, size distributions obtained by measuring the diameters of deposited droplets differ considerably from those of the droplets as they exist in the aerosol.

Although the replica method[1] was developed chiefly for electron microscopy, it can conveniently be used for light microscopy; for the examination of tobacco smoke droplets, it virtually increases the resolving power by a factor of 2·3.

The samples taken on collodion film were re-photographed at a higher magnification (×10,000) and crystalline inclusions were observed in many of the spread droplets (Fig. 1c). It is not known whether these crystals (mostly in the size range 0·02–0·04μ) existed in the droplet phase or whether they were the result of some constituent crystallizing out under vacuum in the electron microscope. Kahler and Lloyd[6] found spherical particles of approximately the same size range in cigarette and cigar smoke, and it is possible that the physical form of included particles is some characteristic of the brand of tobacco from which the smoke has been formed.

This application of the replica method was suggested by Mr. H. L. Green, and helpful discussion with him is gratefully acknowledged.

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Helium–Butane Gas Mixtures as Fillings for Geiger-Müller Tubes

Gas-flow counters are finding an increasing use, especially in automatic methods of counting carbon-14 and tritium in sample-changing devices, and in chromatogram scanners. We have investigated the performance of various mixtures of counting gases in order to determine the factors affecting the choice of an optimum mixture. The gases investigated consisted of helium containing 1·0–2·5 per cent of butane; helium bubbled through ethanol at 0° C. (containing about 1·6 per cent ethanol vapour); and, as standards of reference, 'Tracerlab *G*–1 Geiger Gas' (composition, according to manufacturers, principally helium, *iso*butane, and butadiene, in undisclosed proportions) and 'Nuclear-Chicago *Q*–Gas' (containing nominally 98·7 per cent helium + 1·3 per cent butane).

Curves of counts per minute against voltage (in 50-V. intervals) were recorded to show the usual plateau for each gas in two very different types of gas-flow counter, as described below. Two carbon-14 standard planchettes were used, one for each type of counter. The curves were analysed to give (*a*) the plateau length; (*b*) the operating voltage, taken as one-third of the plateau length above the lower limit of the plateau; (*c*) the slope of the plateau at the operating voltage; and (*d*) the counts per min. of the standard planchette at the operating voltage.

Counter 1 was a Scott-type end-window gas-flow counter[1] used for exploring two-dimensional paper chromatograms and for planchette counting. The end window consisted of I.C.I. 'Melinex 0' (25 gauge), a polyethylene terephthalate film of thickness 0·00625 mm. (0·86 mgm. per cm.²). The diameter of the window and of the cylindrical counting volume was 5·6 cm. The anode was an axial tungsten wire of 0·13 mm. diameter and 1·5 cm. length, supported from the top of the counter tube on a thin brass pillar, and terminating in a glass bead placed about 0·3 cm. behind the window. The carbon-14 planchette was 2·4 cm. in diameter. The counter was used with a 'Nuclear-Chicago Ultrascaler 192*A*', with the input sensitivity set at 60 mV. This input sensitivity was chosen after a series of 15 runs at different sensitivities between 1 and 800 mV., and has been extensively used in routine operation. Measurements were made at three different gas-flow rates for each gas mixture: 127, 287, and 613 ml. per min., corresponding to a positive pressure inside the counter of 1·2, 2·4, and 4·8 cm. of ethanol, respectively. 1-min. counts were taken.

Counter 2 was a standard 'Nuclear-Chicago *D*–47' counter mounted on a '*C*–110*B*' sample changer, and

Table 1. Summary of Results in Scott Counting Tube

Gas mixture	Plateau length (V.)	Operating voltage (1/3 from bottom of plateau)	Counts/min. of standard carbon-14 planchette at operating voltage	Plateau slope at operating voltage (per cent/100 V.)
He + 1·0 per cent butane	350	1,600	15,300	4·0
He + 1·1 per cent butane	650	1,825	14,750	3·7
He + 1·5 per cent butane	700	1,900	14,600	1·7
He + 2·0 per cent butane	750	2,100	14,500	0·7
He + 2·5 per cent butane	700	2,200	14,450	0·3
He + ethanol	500	2,050	14,600	2·8
'Nuclear-Chicago Q-Gas'	750	2,050	14,350	1·0
'Tracerlab G-1 Geiger Gas'	300	1,650	14,400	1·4

connected to the 'Ultrascaler 192*A*'. The tube was used without a window, and the carbon-14 sample occupied an area 1·5 cm. in diameter on a metal planchette. The counting volume was approximately trochoidal in section, with a base diameter of 3·6 cm. The anode was of 0·05-mm. diameter tungsten wire in the form of a horizontal loop 1·5 cm. in diameter placed centrally, and about 1·3 cm. above the planchette. The operating conditions were those recommended by the manufacturers: gas-flow rate 50 ml. per min. after a preliminary flushing period at 200 ml. per min., and the scaler input sensitivity at 250 mV. The counts were each of 3-min. duration.

Tables 1 and 2 give the summarized results from each counter. Of the three flow-rates used in the Scott counter, the lowest was insufficient to sweep out the decomposition products of the discharges, so that the plateau was short and breakdown occurred at relatively low voltages. Increasing the flow-rate gave longer and flatter plateaux, but the difference between the two higher rates of gas flow was not sufficiently great to justify the highest consumption of gas. The results are therefore given for the medium flow-rate of 287 ml. per min. Tables 1 and 2 agree in the comparison of the mixtures investigated with the commercially available gases. Helium + 1·1 per cent butane, and helium + 1·5 per cent butane possessed characteristics closely resembling those of 'Tracerlab *G*-1 Geiger Gas' (except that the 'Tracerlab Gas' showed a smaller plateau slope); the 'Nuclear-Chicago *Q*-Gas' characteristics were in all respects between those of helium + 1·5 per cent butane and helium + 2·0 per cent butane, although the manufacturers stated that this gas consisted of helium + 1·3 per cent butane. The helium + ethanol mixture operated at a relatively high voltage, as did helium + 2·0 per cent butane, but the ethanol plateau was much shorter and steeper (Table 1).

Table 2. Summary of Results in *D*-47 Gas-Flow Counter

Gas mixture	Plateau length (V.)	Operating voltage (1/3 from bottom of plateau)	Counts/min. of standard carbon-14 planchette at operating voltage	Plateau slope at operating voltage (per cent/100 V.)
He + 1·0 per cent butane	150	1,000	1,920	4·0
He + 1·1 per cent butane	300	1,250	1,910	4·2
He + 1·5 per cent butane	350	1,300	1,885	3·3
He + 2·0 per cent butane	350	1,500	1,890	2·0
He + 2·5 per cent butane	350	1,550	1,920	1·3
'Nuclear-Chicago Q-Gas'	400	1,400	1,900	2·0
'Tracerlab G-1 Geiger Gas'	350	1,250	1,900	1·1

These results show that certain helium–butane mixtures from the range investigated are entirely suitable as counting gases. The practical choice is between the 1·5 per cent and the 2·0 per cent proportion of butane. The higher proportion gave a considerably flatter plateau, but also a rather higher operating voltage. Even with a counter tube as large as the Scott-type counter, the helium + 1·5 per cent butane mixture required an operating voltage of less than 2 kV., which is within the range of most commercial high-voltage supplies fitted to scalers. As most counter tubes are smaller than the Scott type, the operating voltage would be well below 2 kV., as was in fact found with the *D*–47 tube.

We wish to thank Dr. A. Bracken of British Oxygen Research and Development, Ltd., for the helium–butane gas mixtures. The Scott-type counter tube was constructed by Mr. L. D. Kitchen and Mr. S. T. Smith of the Physics Department, King's College Hospital. The Nuclear-Chicago counting equipment was a gift from Miles Ames Laboratories to Prof. C. H. Gray.

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[1] Fuller, R. C., *Science*, **124**, 1253 (1956).

METALLURGY

The Delta Plutonium Transition Temperature

Since the first reports of the allotropes of the element plutonium[1], one aspect of continuing interest has been the existence of the δ'-phase occurring in the temperature-range 450–480° C. Recent determination of the latent heats of transition of the allotropes of plutonium[2] enable the thermodynamic aspect of the effects of alloying elements (at impurity-level concentrations) on the $\delta \rightleftharpoons \delta'$ transition to be considered.

It has been pointed out that the phase rule, commonly applied in the construction of equilibrium diagrams, is but one of a number of rules all of which are based on the same thermodynamic reasoning[3]. One of these rules is that when a polymorphic reaction occurs in one of the pure components, the initial slopes of the phase boundaries meeting at the transition temperature differ by $(L/RT^2)^{-1}$, where L is the latent heat, T the absolute temperature of the transition and R the gas constant. Applying this rule to the $\delta \rightleftharpoons \delta'$ transition for which L is 17 ± 10 cal./gm.-atom and T is 728° A., the difference in slopes of the phase boundaries is 620° C./atomic per cent. This very high value implies that small quantities of added elements may have a marked effect on the observed transition temperature. For the limiting condition that one of the phase boundaries of the

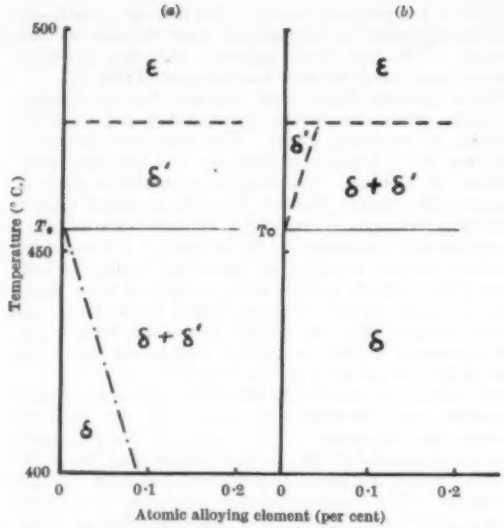

Fig. 1. Limiting cases for the effect of alloying elements on the $\delta \rightleftharpoons \delta'$ transition in plutonium

two-phase region $\delta + \delta'$ has zero slope (thereby minimizing the effect of alloying elements on the transition temperature) the other will have a slope of absolute value 620° C./atomic per cent. In Fig. 1 (*a*), the impurity addition does not affect the lower limit of the pure δ' region, whereas in Fig. 1 (*b*) the region is effectively eliminated by the addition.

The probability of the effect of any specific impurity being one of these limiting cases is thought to be small. Since the slopes of the phase boundaries must both have the same sign, it is probable that in most cases corresponding to Fig. 1 (*a*) the phase boundaries meeting at T' (the pure metal transition temperature) will both be tilted downwards. For alloys corresponding to Fig. 1 (*b*), both boundaries will be tilted upwards—making it even less likely that the δ' plutonium structure will be observed. In view of the appreciable concentration of impurities present in nominal 'high purity' plutonium, in those materials where the pure δ'-phase is observed, the situation must be represented by a variation of Fig. 1 (*a*), which is shown diagrammatically in Fig. 2.

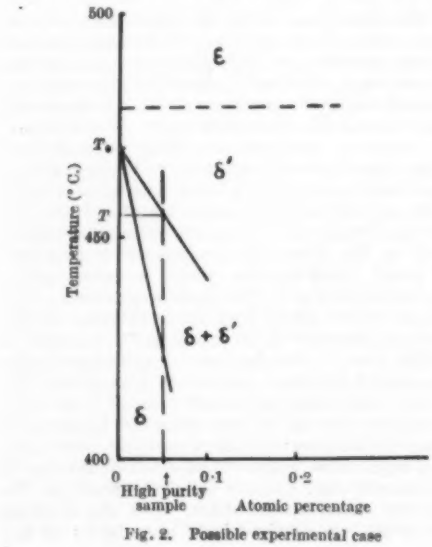

Fig. 2. Possible experimental case

From this figure it is obvious that the transition T observed in 'high-purity' metal may be a low approximation to the true transition temperature T_0. This observation is of particular interest owing to the small temperature-range of existence of δ' (about 25 deg. C.).

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CRYSTALLOGRAPHY

Growth of Single Crystals of Copper

In his communication on the growth of single crystals of copper, published in *Nature* of April 2, p. 33, Mr. D. S. Kemsley is good enough to refer to a paper by Andrade and Roscoe[1], in which was described a method suitable for growing single crystals of metals of low melting point.

He makes, however, no reference to a paper published some years later by Andrade and Henderson[2], which specifically states that this method is not suitable for growing crystals of metals of higher melting point and describes a method using a split graphite mould in a high vacuum. This method was used for preparing single crystals of gold, silver and nickel in the first place, and was afterwards used by Andrade and Aboav[3] for preparing single crystals of copper, which proved perfectly satisfactory.

Those who wish to prepare single crystals of copper may possibly find this method simple and well adapted to the purpose.

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Crystal Structure of Potassium Trivanadate

When solutions of potassium vanadate are made weakly acid, with *p*H less than 6·5, the orange polyion $V_{10}O_{28}^{-6}$ is formed. These solutions are unstable, and on long standing or on heating, insoluble light-orange, flaky crystals of potassium trivanadate, KV_3O_8, are precipitated. This compound was evidently first described by Norblad[1].

Buerger precession and Weissenberg X-ray diffraction patterns of crystals of potassium trivanadate

show a monoclinic lattice with the dimensions: $a = 7{\cdot}63$ Å., $b = 8{\cdot}43$ Å., $c = 4{\cdot}97$ Å. and $\beta = 96° 45'$. The space group is $P2_1/m$ or $P2_1$, and the unit cell contains 2 formula units. The largest crystals are less than 0·1 mm. in the longest dimension, and grow as irregular stacks of thin platelets parallel to (100), somewhat elongated along the c axis. The optical properties were determined as follows (by A. van Valkenburg, U.S. National Bureau of Standards):

$\alpha = 1{\cdot}78$, $X \sim \perp$ (100), lemon yellow
$\beta = 2{\cdot}25$, $Y = b$, orange
$\gamma = 2{\cdot}34$, $Z \sim \parallel c$, orange
$2V = 26°$ (negative)

γ was measured with sulphur-selenium melts, and β was estimated from the other measured results.

The diffraction intensities of the ($hk0$), ($0kl$) and ($h0l$) reflexions, which were used for the structure determination, were determined from the multiple photographs by visual comparison with a calibrated strip made with one crystal reflexion. Owing to the imperfect nature of the crystals, these data were not as accurate as one usually expects, so that refinement of the structure was somewhat hampered. The trial structure was obtained from the three Patterson projections and spatial considerations. Refinement of this structure proved to be troublesome by Fourier methods, owing to serious atom overlaps in all three projections. Application of the powerful least-squares programme (which solves the full matrix of the normal equations) written by Busing and Levy of the Oak Ridge National Laboratories for the IBM Type 704 computer, finally brought the agreement between observed and calculated structure factors to a satisfactory state. No evidence has been found to indicate that the structure departs from centrosymmetry, and the accepted space group is $P2_1/m$. At present, the reliability factors are as follows: $R(hk0) = 17{\cdot}8$ per cent, $R(0kl) = 11{\cdot}3$ per cent and $R(h0l) = 13{\cdot}1$ per cent; overall $R = 14{\cdot}0$ per cent. The corresponding parameters are given in Table 1.

Table 1. PARAMETERS FOR POTASSIUM TRIVANADATE
Space group $P2_1/m$ (Int. Tab. No. 11)

Atoms	x	y	z
2K in (e)	0·062	¼	0·945
$2V_1$ in (e)	0·577	¼	0·917
$4V_2$ in (f)	0·693	0·057	0·441
$2O_1$ in (e)	0·415	¼	0·109
$2O_2$ in (e)	0·759	¼	0·595
$4O_3$ in (f)	0·516	0·101	0·700
$4O_4$ in (f)	0·518	0·063	0·441
$4O_5$ in (f)	0·744	0·092	0·130

The structure, as illustrated in Fig. 1 projected along the a axis, consists of a sheet arrangement of fused VO_6 octahedra, with potassium ions occupying interlayer positions. Two-thirds of these octahedra are linked into zig-zag chains stretched parallel to the b axis; the remaining one-third lie on the mirror planes and tie these chains into layers parallel to the b and c axes. Although the V—O bond-lengths are not accurately known ($\pm$ 0·1 Å.), it is apparent that the octahedra are highly distorted. For the vanadium atom on the mirror plane, the distances are 1·65, 1·69 (2), 2·01 (2) and 2·24 Å.; for the other vanadium atom they are 1·58, 1·66, 1·85, 2·01, 2·13 and 3·01 Å.

The structure found for KV_3O_8 has been confirmed also for the isostructural CsV_3O_8 by H. T. Evans, jun. (personal communication), and has reached a better degree of refinement, owing to the better quality of crystals formed by the cæsium compound. Details of the analysis of both these structures will be published elsewhere. There is, incidentally, no relation between these structures and that of KCr_3O_8 recently described by Wilhelmi[3].

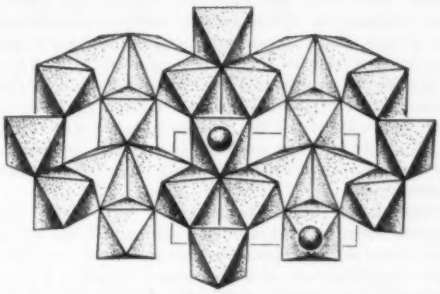

Fig. 1. The layer co-ordination structure of potassium trivanadate projected along the a axis. Two of the interlayer potassium ions are shown as shaded circles. (Drawn by H. T. Evans, jun.)

I wish to express my thanks to J. D. H. Donnay for his encouragement and guidance of the work described; and to H. T. Evans, jun., of the U.S. Geological Survey, who suggested the problem, for his helpful discussions and guidance. Thanks are also due to the latter for providing computer facilities, and to P. O'Hara of the National Bureau of Standards for his assistance with the IBM Type 704 computer.

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[1] Norblad, J. A., *Bull. Soc. Chim.*, **23**, 64 (1875).
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Electron Microscopy and the Crystal Structure of Indanthrene

IN the course of work on the direct observation of crystal lattices using high-resolution electron microscopy, indanthrene ($C_{28}H_{14}O_4N_2$) has been examined in a manner similar to that used by Menter[1] with phthalocyanine ($C_{32}H_{18}N_8$) and its metal derivatives.

The crystal structure of indanthrene has been ascertained by Bailey[2] using conventional X-ray techniques: he finds the crystal to be monoclinic, space group P^2_1/a, with two molecules in the unit cell and the following dimensions: $a = 30{\cdot}83$ Å.; $b = 3{\cdot}833$ Å.; $c = 7{\cdot}845$ Å.; $\beta = 91° 55'$ (see Fig. 1).

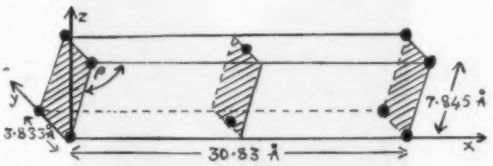

Fig. 1. Indanthrene: the unit cell

The work with the electron microscope bears out those values he obtained for lattice translations a and b, but, more important, it adds further evidence that images seen in the microscope are in fact images of planes of molecules and are not merely fringes formed by electron diffraction. Labaw and Wyckoff[3], in their study of the derivative indanthrene scarlet R ($C_{28}H_{22}N_2O_4$), were unable to use the technique of electron micro-diffraction and left this question unresolved.

Crystals of indanthrene, platy but with very ill-defined terminal faces, were deposited on specimen grids from a suspension in acetone, and examined at high magnification in a Siemens Elmiskop I electron microscope operated at 80 kV. Parallel fringes lying along the length of the crystals were frequently observed (Fig. 2) and comparison of the spacing of these fringes with that of the '(20$\bar{1}$) planes' of platinum phthalocyanine (11·94 Å.) in photographs taken under identical conditions gave a value of 15·2 ± 0·4 Å.

Electron micro-diffraction photographs such as that in Fig. 3 from the circular region of the 'raft' of crystals in Fig. 4 have the characteristic appearance of fibre photographs. Measurements of the distance apart of neighbouring layer lines of the fibre pattern indicate that the maximum period of the lattice structure along the fibre axis is 3·86 ± 0·13 Å., and measurements in a perpendicular direction along the central layer line produce a spacing of 15·51 ± 0·21 Å. Observation of the diffraction pattern in the electron microscope shows that it is only the innermost two spots on the central layer line which are uncovered by the objective aperture in normal microscopy conditions. Thus only the diffracted beams from a structure of period ~ 15·5 Å. are allowed to produce an image on the electron microscope screen after recombination by the later electron lenses.

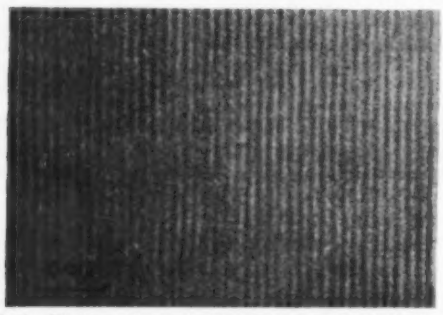

Fig. 2. Electron micrograph of part of a crystal of indanthrene (× 1,000,000)

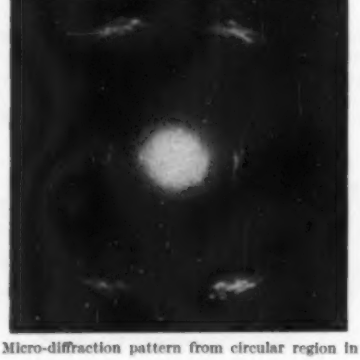

Fig. 3. Micro-diffraction pattern from circular region in Fig. 4

Fig. 4. A 'raft' of indanthrene crystals (× 60,000)

It is compatible with these observations that the crystals examined were platy on {001}, with small {100}, that those planes separated by lattice translations $a/2$ and b give rise to the diffraction pattern observed, and that the (200) planes of indanthrene are directly imaged in the electron microscope under normal conditions.

I thank Dr. F. P. Bowden for his help, Dr. J. W. Menter for discussion, the Department of Scientific and Industrial Research for a research grant, and the Imperial Chemical Industries, Ltd., for crystal specimens.

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Crystal Structure of Mellitic Acid

In a recent communication, Bezjak and Grdenić[1] have described the crystal structure of mellitic acid ($C_6(COOH)_6$). I have also recently completed an independent and full refinement of the structure[2]. While there is agreement on the general features of the structure, my conclusions are different, and are that :

(1) The twelve independent C—O bonds are not identical, but have lengths ranging from 1·18 ± 0·03 to 1·34 ± 0·03 Å. (Bezjak and Grdenić quote them all as 1·23 ± 0·01 Å.). The variations of bond-lengths within the carboxyl groups are consistent with the variations in the C—C—O bond angles.

(2) Within each layer there are six inter-molecular contacts of lengths between 2·64 and 2·68 Å. for each molecule. As these are the lengths expected for hydrogen bonds from the infra-red evidence[3,4], and

correspond to the number of hydrogens in the structure, they are assumed to be the hydrogen bonds. The two contacts of 2·68 Å. between oxygens in different layers given by Bezjak and Grdenić are found to be 2·90 and 3·06 Å. by me, and are not considered to be hydrogen bonds.

A further point of more general application may be made concerning the possible ambiguity of structures solved in projection only, when the space group has fairly high symmetry. The present structure serves as an example.

The space group *Pccn* has eight equivalent general positions given by :

$$x,y,z\ ;\ \tfrac{1}{2}-x,\tfrac{1}{2}-y,z\ ;\ \tfrac{1}{2}+x,\bar{y},\tfrac{1}{2}-z\ ;\ \bar{x},\tfrac{1}{2}+y,\tfrac{1}{2}-z\ ;$$
$$\bar{x},\bar{y},\bar{z}\ ;\ \tfrac{1}{2}+x,\tfrac{1}{2}+y,\bar{z}\ ;\ \tfrac{1}{2}-x,y,\tfrac{1}{2}+z\ ;\ x,\tfrac{1}{2}-y,\tfrac{1}{2}+z.$$

If the y co-ordinate is replaced by $\frac{1}{4}-y$, the eight positions become :

$$x,\tfrac{1}{4}-y,z\ ;\ \tfrac{1}{2}-x,y,z\ ;\ \tfrac{1}{2}+x,\tfrac{1}{2}+y,\tfrac{1}{2}-z\ ;\ \bar{x},\bar{y},\tfrac{1}{2}-z\ ;$$
$$\bar{x},\tfrac{1}{2}+y,\bar{z}\ ;\ \tfrac{1}{2}+x,\bar{y},\bar{z}\ ;\ \tfrac{1}{2}-x,\tfrac{1}{2}-y,\tfrac{1}{2}+z\ ;\ x,y,\tfrac{1}{2}+z\ ;$$

which are different in three dimensions, but give the same set of positions in all three axial projections, $0kl$, $h0l$ and $hk0$. This may easily be seen from the two sets of co-ordinates given. Exactly this ambiguity between y and $\frac{1}{4}-y$ exists for each carboxyl group in the crystal structure of mellitic acid, as the carbon framework of each molecule lies approximately in the plane $y = \frac{1}{4}$ or $y = \frac{3}{4}$. Thus whether a carboxyl group is rotated clockwise or anti-clockwise about the C—C bond joining it to the ring depends on whether the oxygens have co-ordinates y or $\frac{1}{4}-y$. With four independent carboxyl groups per molecule and two independent molecules in the structure, there are 2^8 or 256 possible structures which will give identical projections, and they can be distinguished only by using some general reflexions. Between different carboxyl groups within the same molecule, all but four of these possible structures give oxygen–oxygen contacts which are too small. I used $h1l$ and $h3l$ reflexions to distinguish between these four possibilities.

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[1] Bezjak, A., and Grdenić, D., *Nature*, **185**, 756 (1960).
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RADIATION CHEMISTRY

Radiation-induced Changes in α-Lead Azide

Using techniques of micro-hardness determination already described[1] and standard methods of X-ray diffraction analysis, preliminary changes in the lattice of X-irradiated α-lead azide have been measured and decomposition products analysed. Specially grown 99·9 per cent pure 1 mm. crystals were used to determine hardness changes and microcrystalline 99·5 per cent pure azide material used in the parameter studies. Nickel-filtered 45-kVp. copper radiation with a half-value layer in aluminium of 0·06 mm. was used to produce and record the parameter changes,

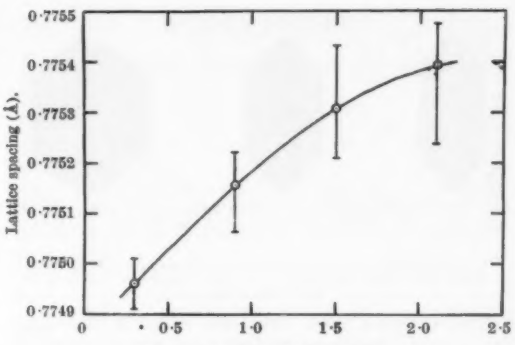

Fig. 1. Mean increase in an unindexed lattice spacing of α-lead azide with X-ray dose, at a dose-rate of 5·0 × 10⁸ röntgens/min. in air. The spread of the results used for each graphical point is indicated

whereas somewhat harder radiation with a half-value of 0·09 mm. and from a tungsten tube operated at 50 kVp. was used (*a*) to induce hardness changes and (*b*) to bring about ultimate decomposition of the azide. Approximate dose-rates in each series of experiments were 5·0 × 10² röntgens/min., 2·5 × 10⁴ röntgens/min. and 1·4 × 10⁵ röntgens/min. respectively.

To study parameter changes the highest reflexion recorded with copper $K\alpha_1$ was selected for measurement. This could not be indexed, but was calculated to refer to an uncorrected spacing of 0·7749$_6$ Å. at 70° F. with a measured temperature coefficient of 0·00002 Å./deg. F. Fig. 1 shows increase in this parameter with increasing X-ray dose. Six trials were carried out and each graphical point is the mean of six determinations with experimental error as shown. Serious loss of line-to-background intensity terminated the series before saturation if any could be effectively observed, and within the scope and experimental accuracy of the work, it was not possible to test critically for any relaxation with time or instability to light. Qualitatively similar results were obtained for other parameters.

Hardness changes for the 013 form ($a<b<c$) of α-lead azide undergoing X-irradiation were measured at 10-gm. load. Five dual trials were carried out, and it was readily apparent that the hardness increases noted were not permanent but

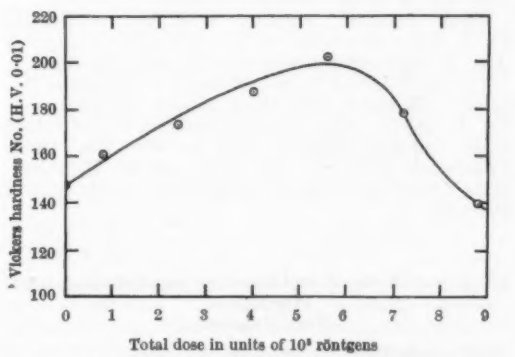

Fig. 2. Showing the increase in Vickers hardness at 10 gm. load for the 013 form of an α-lead azide crystal while receiving X-rays at a dose-rate of 2·5 × 10⁴ röntgens/min. in air

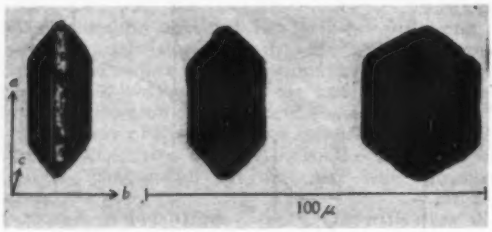

Fig. 3. Showing the anomalous *b*-axis expansion in the habit of a single crystal of α-lead azide receiving X-rays at a dose-rate of $1{\cdot}4 \times 10^5$ röntgens/min. in air

tended to relax with time and even in the dark. Fig. 2 relates hardness to dose for a run in which all operations were carried out with maximum speed. Five indentations were used to derive each graphical point, good consistency being obtained.

Changes in parameter[2] and mechanical properties[3] have already been observed in other irradiated materials and are generally ascribed to vacancy production. If, as is probable, decomposition of α-lead azide proceeds by electron transfer from azide ions to liberate free nitrogen, this would result in vacancy production consistent with the results obtained.

Optical, gravimetric, and X-ray methods were used to study more extensive X-ray damage in the α-lead azide, both in air up to a total dose of $3{\cdot}4 \times 10^8$ röntgens and corresponding to more than 97 per cent destruction of the azide, and in a number of other atmospheres. Although the ultimate X-ray product in vacuum or under an inert atmosphere is necessarily lead, this is not encountered in the presence of carbonic acid or of water. Thus, X-ray studies show that the stable end-product of X-ray decomposition in normal air is basic lead carbonate of the formula $2PbCO_3.Pb(OH)_2$, whereas in severe deficiency of carbon dioxide but excess of water vapour, amounts of basic lead azide of unestablished formula[4] are formed. The latter may be finally converted into basic lead carbonate by X-irradiation in normal air.

X-ray examination of a single crystal of α-lead azide undergoing decomposition to disoriented basic lead carbonate shows that the conversion is complex. After a dose of $6{\cdot}7 \times 10^7$ röntgens there is evidence for partially disoriented residual lead azide together with a disoriented unidentified phase. Higher doses produce a further unidentified phase before stable basic lead carbonate is finally formed.

These features, together with the anomalous *b*-axis habit expansion of the decomposing crystal (Fig. 3), have not yet been satisfactorily explained.

We are indebted to the Ministry of Aviation Explosives Research and Development Establishment for the supply and chemical analysis of the α-lead azide starting material, and to the War Office Armament Research and Development Establishment Chemical Services Branch for miscellaneous analyses.

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Modes of Radiation-induced Cross-Linking in Hydrocarbon Polymers

Since the earliest observations[1,2] on the cross-linking of organic polymers by ionizing radiation, much research has been devoted to this phenomenon, but there remains no generally accepted mechanism applicable to all polymers[3]. For polyethylene it has been proposed[4] that linkages between molecules arise from three independent processes:

(*a*) By the direct action of ions according to either an ion–molecule–electron reaction as originally suggested by Dole[1] and represented in (1):

$$\begin{matrix} \diagdown \\ CH_2^+ \\ \diagup \end{matrix} + \begin{matrix} \diagdown \\ CH_2 \\ \diagup \end{matrix} + e^- \rightarrow \begin{matrix} \diagdown \\ CH \\ \diagup \end{matrix} — \begin{matrix} \diagdown \\ CH \\ \diagup \end{matrix} + H_2 \qquad (1)$$

or by an ion–molecule process followed by subsequent neutralization of the product ion by its cognate electron[5,6].

(*b*) From the interaction of free radicals of low mobility primarily formed in crystalline regions of the polymer[7], as in a post-irradiation fusion of the solid.

(*c*) As a result of the decay of unsaturation initially present and of the unsaturated groups formed during radiolysis[8]; in this case an end- or cross-link would result depending upon the position of the unsaturated group in the polymer. It has been postulated that the mechanism of this process occurs by excitation energy transfer from the main polymer chain[8,9].

A recent paper by Black and Lyons[10] on the radiolytic changes incurred in polypropylene indicates that the formation of vinylidene double bonds corresponds to the occurrence of main-chain fracture according to (2):

$$R\text{–}[\text{–}\underset{\displaystyle CH_3}{\underset{|}{CH}}\text{—}CH_2\text{–}]\text{–}R_1 \text{–}\sim\sim\rightarrow R\text{—}\underset{\displaystyle CH_3}{\underset{|}{C}}=CH_2 + R_1H \qquad (2)$$

Further, at doses exceeding $5{\cdot}0 \times 10^{21}$ eV. gm.$^{-1}$, it is shown that the sol fraction–dose relationship for this irradiated polymer is in accordance with an expression derived by Charlesby[11] on the assumption that the ratio of cross-linking to chain fracture approaches unity. These results are interpreted[10] in terms of a mechanism whereby an excited intermediate state of the polymer leads either to fracture F or cross-linking C, the latter process depending upon the concentration $[F]$ of stable chain fragments, that is, vinylidene groups, arising from previous fracture processes during irradiation.

If the processes of vinylidene group growth and decay in polypropylene are considered analogous to the kinetics of *trans*-vinylene formation in polyethylene[8], the corresponding relation:

$$\frac{dF}{dD} = \varphi_f - k_f[F] \qquad (3)$$

would be expected to hold where φ_f refers to the initial rate of chain fracture and k_f is the decay constant for vinylidene groups leading to cross-linking. Since the vinylidene groups are located at the ends of fractured chains, that is, *iso*propenyl groups, it is more correct to refer to their disappearance by end-linking. In formulating equation (3) the process leading to fracture as represented by φ_f is considered to be independent of the magnitude

of the subsequent decay process governed by $k_f[F]$ and thus differs from the competitive reaction mechanism envisaged by Black and Lyons[10]; studies on polyethylene have shown[8] that the initial rate of *trans*-vinylene formation is not reduced by a higher initial vinyl group concentration in the polymer so there would appear to be no direct competition between unsaturation formation and disappearance in this system. A test of equation (3) is provided by the data of Black and Lyons in Fig. 4 of their paper[10]; neglecting the two points at low-irradiation doses, the remainder of the results conform to a reasonable linear relation between $\frac{dF}{dD}$ and $[F]$ with a k_f value of 0·094 Mrad^{-1} or 1·51 × 10^{-21} gm. eV.$^{-1}$. It is of special interest that this latter value compares closely with the decay constant of 1·49 × 10^{-21} gm. eV.$^{-1}$ previously obtained for initial vinylidene decay in a sample of high-pressure polyethylene[8]. At high doses it follows directly from equation 3 that the rate of cross-linking would equal the rate of fracture at a limiting concentration of vinylidene groups formed by fracture, in agreement with experiment.

The evidence cited suggests that the cross-linking of polypropylene depends mainly on the process (*c*) above; by contrast, the cross-linking of saturated polyethylene chains in the initial stages of irradiation proceeds chiefly according to (*a*) and (*b*), the latter contribution depending upon the crystallinity of the sample and the post-irradiation treatment[7,12]. In general, the importance of (*c*) will depend on the concentration of unsaturation in the polymer, whether initially present or formed during irradiation, and hence on the irradiation dose. The relatively low cross-linking yields reported for highly unsaturated polymers (rubber, polybutadiene, etc.) by comparison with the measured decay of unsaturation[9,13] suggest that in such cases the main reaction is the formation of internal links by process (*c*) within the polymer chains aided by the coiled configuration of the molecule in the amorphous state[14]; in this connexion it is noteworthy that Roberts and Mandelkern[15] have observed that the cross-linking of rubber is much increased if the irradiation is carried out on the highly oriented polymer whereas for polyethylene the cross-linking is greater in the liquid state[4,7].

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GEOCHEMISTRY

A New Interpretation of the Mullite Problem

The published phase diagrams for the Al_2O_3–SiO_2 system have been many and varied. Bowen and Grieg[1] maintained that mullite of invariable composition $3Al_2O_3.2SiO_2$ (71·8 weight per cent Al_2O_3) is the only stable alumino-silicate found at high temperatures in this system. Several workers have since found homogeneous mullites containing from 75 to as much as 82·6 per cent Al_2O_3, and it is at present generally accepted that continuous mullite solid solutions exist at least over the range $3Al_2O_3.2SiO_2$–$2Al_2O_3.SiO_2$ (71·8–77·3 per cent Al_2O_3). Some investigators also claim the existence of mullites intermediate in composition between sillimanite ($Al_2O_3.SiO_2$) and $3Al_2O_3.2SiO_2$, although continuous solid solution between these compositions has never been authenticated. More recently, the melting behaviour of mullite has been disputed, some workers adhering to Bowen and Grieg's belief that mullite melts incongruently, whereas others maintain that no decomposition into corundum and liquid occurs during melting, and that therefore mullite melts congruently.

Recently it has become possible to observe the behaviour of melts directly by hot-stage microscopy, instead of having to rely solely on the indirect techniques of quenching or thermal analysis used by previous investigators. The application of this new technique to a study of the Al_2O_3–SiO_2 system appears to have resolved some of the outstanding questions, particularly in regard to the melting behaviour and constitution of mullite. Briefly, direct observations have been made on $3Al_2O_3.2SiO_2$ compositions near the liquidus temperature which show repeatedly that corundum crystals, whether present in the starting material or obtained by appropriate undercooling of the melt, are entirely dissolved by the liquid in the presence of residual mullite. The survival of corundum has been observed only when prolonged heating has caused the melt composition to change through volatilization of silica, or when the temperature of the melt has been increased without regard to the much slower rate at which corundum dissolves as compared with mullite.

These observations therefore support the view that the $3Al_2O_3.2SiO_2$ composition, under conditions of equilibrium, does not form corundum during melting; the corollary, that mullite melts congruently, is also disproved, however, by the following observations. Heated melts of $3Al_2O_3.2SiO_2$ composition tend to lose silica by volatilization. Despite this tendency, such melts contain an appreciable amount of siliceous residual glass after mullite single crystals have been grown from them on the microscope hot-stage. The inference that these mullite single crystals must be more aluminous than the parent composition has been checked by chemical separation and analysis. Such crystals were found to contain 77·2 per cent Al_2O_3 (cf. $2Al_2O_3.SiO_2 \equiv 77·3$ per cent and $3Al_2O_3.2SiO_2 \equiv 71·8$ per cent Al_2O_3). Refractive indices of these crystals measured in sodium light gave $N_\alpha = 1·638$, $N_\gamma = 1·653$. Identical indices were reported by Wright[2] for crystals obtained by fusion of an $Al_2O_3.SiO_2$ composition, and the same figures have been quoted by Larsen and Berman[3] for 'artificial mullite'. Different heat treatments have been used to prepare mullites the analysed Al_2O_3

contents of which have ranged from 79·5 down to 75 per cent, the median being represented approximately by $2Al_2O_3.SiO_2$ (77·3 per cent). The refractive index measurements show an apparently linear relation with composition as shown in Fig. 1. From this diagram the supposedly constant refractive indices of mullite reported by Bowen and Grieg[1] could in fact represent mullites containing some 75–77 per cent Al_2O_3, if allowance is made for the stated accuracy of their measurements ($N_\alpha = 1{\cdot}642$, $N_\gamma = 1{\cdot}654$ ($\pm 0{\cdot}003$)).

The mullite containing the least amount of Al_2O_3 (75 per cent) was crystallized from a $CaO–Al_2O_3–SiO_2$ melt over the temperature-interval 1,550–1,500° C., that is, at a temperature below the reported solidus for the system $Al_2O_3–SiO_2$. It is probable, therefore, that the mullites the optical properties of which have been described by other investigators lie much closer in composition to $2Al_2O_3.SiO_2$ than $3Al_2O_3.2SiO_2$, and that the synthesis of true $3Al_2O_3.2SiO_2$ is only likely to be successful at temperatures well below the $Al_2O_3–SiO_2$ solidus.

During the investigation some unusual forms of mullite were encountered. Seen under the microscope, these appeared to be almost or completely homogeneous, and they were characterized by lowered refractive index, birefringence, and $2V$ as compared with normal mullites. They occurred in rapidly cooled melts of more siliceous composition than $3Al_2O_3.2SiO_2$, and are attributed to the almost or completely sub-microscopic intergrowth of mullite and glass. It is hoped to obtain confirmation of this theory by X-ray examination, because a mixed phase of this type apparently cannot be differentiated by optical or chemical methods.

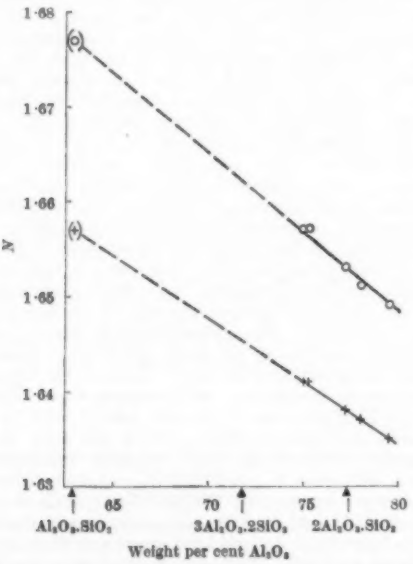

Fig. 1. Variation of refractive index with mullite composition

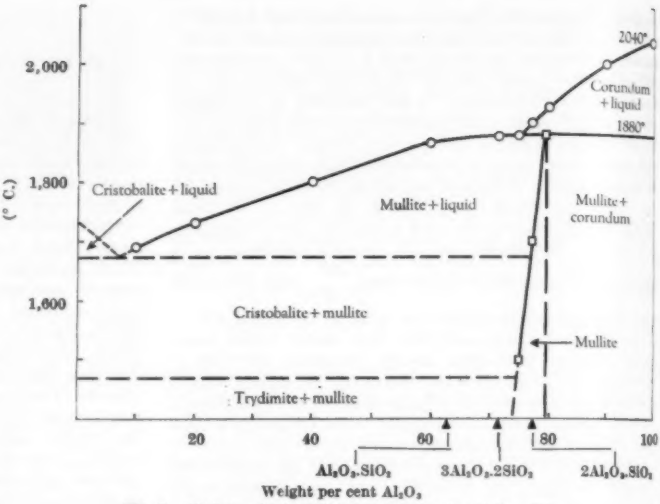

Fig. 2. Redetermined equilibrium diagram for Al_2O_3—SiO_2

Liquidus temperatures have been determined by hot-stage microscopy for a major part of the $Al_2O_3–SiO_2$ system, as shown in Fig. 2. The mullite primary phase region, including the composition $3Al_2O_3.2SiO_2$ which has no special significance, ends at about 75 per cent Al_2O_3, where mullite is transformed peritectically to a mixture of corundum and liquid at 1,880° C.

A detailed account of this work is being presented at the Seventh International Ceramic Congress, London, in May.

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CHEMISTRY

Reaction of Active Nitrogen with Polyethylene

The nature of active nitrogen, the mechanism of its afterglow[1], and its gas phase reactions with organic molecules[2] have been discussed. I have now investigated a heterogeneous active nitrogen reaction at a polymer surface.

'Marlex-50' polyethylene was chosen as the polymer because it has a simple, well-defined structure. It is a high-density, unbranched, highly crystalline polyethylene with polymer chains terminating in one methyl and one vinyl group. Thin sheets of this material were exposed in a flow system to active nitrogen, which was produced by a condensed discharge. Reactions proceeded for periods up to 2 hr. at a pressure of 1·9 mm. mercury, and at temperatures between 39° and 120° C. Condensable products were trapped and analysed quantitatively by vapour phase chromatography and infra-red spectroscopy. The latter was also used to determine the concentra-

tion of vinyl bonds in the polymer. Solubility tests established the extent of cross-linking. The concentration of active nitrogen was obtained from the intensity of the afterglow, which was calibrated by the titration reaction of active nitrogen with nitric oxide[3]. The results of a typical experiment are given in Table 1. The activation energies of the various experimentally determined processes and their probable errors are listed in Table 2.

Table 1. Typical Reaction of Active Nitrogen with Polyethylene

	Product formation:
Temperature, 89° C.	Hydrogen cyanide, 84 per cent
Duration, 60 min.	Cyanogen, 16 per cent
Flow of molecular nitrogen, 610 ml./min.	Total nitrogen equivalent, 60·0 μlitres
Flow of active (atomic) nitrogen, 14·2 ml./min.	Gel formation, 7·1 per cent
Conversion, $N_2 \rightarrow 2N$, 1·1 per cent	Vinyl decrease, 24 per cent
Conversion $N \rightarrow N$ equivalent, $0{\cdot}9 \times 10^{-2}$ per cent	

Table 2. Activation Energies (in kcal./mole)

Hydrogen cyanide formation	$3{\cdot}0 \pm 0{\cdot}5$
Cyanogen formation	$1{\cdot}9 \pm 0{\cdot}7$
Formation of total nitrogen equivalent	$2{\cdot}5 \pm 0{\cdot}6$
Vinyl decrease	$3{\cdot}1 \pm 1{\cdot}2$
Cross-linking (gel formation)	$6{\cdot}3 \pm 1{\cdot}9$

The condensable gas products, the quantity of which varied from 20 to 80 μlitres, contained about 80 per cent hydrogen cyanide, 20 per cent cyanogen, and only traces of ammonia. No derivatives of hydrocarbon fragments were found. Previous reactions of hydrocarbon with active nitrogen in the gas phase gave a maximum formation of 2 per cent cyanogen. In the present less-reactive polyethylene system, the concentrations of hydrocarbon fragments and hydrogen atoms were much smaller than in the comparable gas-phase reaction. The polymer chains were broken but were not fragmented too extensively, and many of the hydrogen atoms were consumed in the process of cross-linking by hydrogen abstraction. Thus, relatively more CN radicals were available for the formation of cyanogen. This also indicated that the CN radical is an important precursor of secondary products in the gas reaction. All C=C double bonds are convenient sites for addition of nitrogen. In 'Marlex-50', 95 per cent of the double bonds are vinyl groups[4], which may initiate a mechanism of chain-unzipping. The remaining 5 per cent of double bonds are vinylene and vinylidene groups, addition to which may lead to scission of the chains. Chain fragments, in turn, will unzip or cross-link.

Up to 10 per cent of the polyethylene was cross-linked by the active-nitrogen reaction. Weight losses amounted to less than 1 per cent. Hence the extent of cross-linking indicated that the reaction was propagated below the surface, either by nitrogen atoms, hydrogen atoms, or free radicals. A mechanism of diffusion would be a reasonable explanation for this observation.

There is a parallelism between reactions due to active nitrogen and those induced by radiation because the physical and chemical properties of a polymer after the nitrogen reaction resemble those after a mild treatment with radiation. Hence, the results of the present investigation can be interpreted by combining the unified mechanism of active nitrogen reactions[2] with established mechanisms of polymer reactions in radiation[5].

(1) *Formation of nitrogen complex.* In the primary process a nitrogen atom can form one of three reaction complexes, at either end of the polyethylene ('Marlex-50') chain or within the chain; for example:

$$CH_2{=}CH{-}[CH_2]_x{-}CH_2 + N \rightarrow CH_2{-}\underset{\displaystyle N}{CH}{-}CH_2{-} \qquad (1)$$

(2) *Formation of nitrogen-containing compound or radical.* Attack on the double bond may be slightly favoured, but all three cases are energetically favourable. The nitrogen atom will attack the C—C bond, rather than the C—H bond and this will lead to splitting-off of either the CN radical, or hydrogen cyanide and hydrogen atoms. The products of reaction 1 may be a new vinyl bond (chain-unzipping) or a chain terminating in a free radical.

$$(1) \rightarrow HCN + H \text{ (or } CN + 2H) + CH_2{=}CH{-} \quad \text{(chain-unzipping)}$$

or

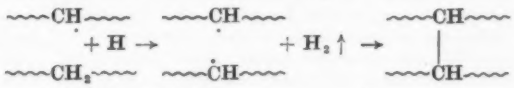
$$(1) \rightarrow HCN \text{ (or } CN + H) + .CH_2{-}CH_2{-} \quad \text{(free radical chain-termination)}$$

(3) *Hydrogen abstraction from polyethylene chain.* Hydrogen is not directly abstracted by nitrogen atoms. This is made possible, however, by the action of the hydrogen atoms liberated in the formation of free radicals:

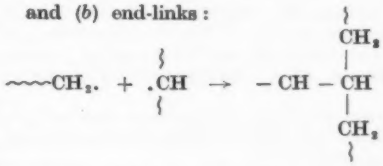
$${-}CH_2{-}CH_2{-}CH_2{-} + H \rightarrow {-}CH_2{-}\dot{C}H{-}CH_2{-} + H_2$$

Cross-linking requires the existence of the radical $-CH_2-\dot{C}H-CH_2-$, because chain ends, such as $.CH_2-CH_2-$, could only couple or unzip. The evidence of cross-linking in depth as shown by gel tests, together with the larger activation energy of cross-linking, points to diffusion of nitrogen (and hydrogen) atoms into the polymer. With free radical chains of two types present, $-CH_2-\dot{C}H-CH_2-$ and $.CH_2-$, two mechanisms of cross-linking are possible:

(*a*) Cross-links of neighbouring chains:



and (*b*) end-links:



I am grateful to my colleagues at the General Electric Research Laboratory for advice and assistance in the course of this work. Special thanks are due to Dr. H. A. Dewhurst for valuable discussions and his continued interest.

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Broadening of the Water Proton Line in High-Resolution Nuclear Magnetic Resonance Spectra of Starch Gels

Reports in the literature of measurements of proton magnetic resonance absorption for starch–water systems have been confined to dilute solutions[1], to starch suspensions in water[2] and to native starch granules containing up to 15 per cent water of crystallization[3]. In this communication we are reporting measurements made on suspensions containing 8 per cent–40 per cent starch and on the gels made by heating these suspensions at 80°. These results are the first to be recorded on starch-gels, and from the broadening of the water line on gelation we have postulated that the effect of hydration on the nuclear magnetic resonance band extends considerably beyond the water which is directly hydrogen bonded on to the starch hydroxyls.

At temperatures between 20° and 50° C. water is absorbed into the amorphous regions of the granules, which swell about 30 per cent by volume[4]. The crystallites remain largely intact, but on heating the suspension at a temperature above 60° some of the crystallites are disrupted, and the granules can swell to about 10 times their original volume if there is sufficient water available. Provided the starch concentration is sufficiently high (usually about 12 per cent with wheat starch) the swollen particles adhere together to form a coherent gel. All the mixtures used in these experiments formed a coherent gel at 80°, apart from the 8 per cent suspension which on heating formed an aqueous suspension of swollen granules.

The nuclear magnetic resonance spectra were obtained on the prototype of the Fairey spectrometer. This comprises a permanent magnet with 4-in. diameter pole faces, a gap of 0·72 in. giving a field of approximately 3,800 gauss at which the ^1H frequency is 16·1 Mc./s. The samples were contained in soda glass tubes of 5·2 mm. outside diameter and approximately 3 mm. inside diameter. Sample spinning at 3,000 r.p.m. was employed and a resolution of 1 part in 10^7 was attained under these conditions. All measurements were made at 35° C. The gels were made by heating the suspensions in the soda-glass tubes for 10 min. at 80°. The gels were then equilibrated for 15 min. in the nuclear magnetic resonance spectrometer at 35° C. before measurements were made.

Symmetrical gaussian curves were obtained at all concentrations, and their widths were measured at half-peak heights.

In all these suspensions and gels the proton magnetic resonance consists of a narrow line (0·4–1·35 p.p.m. wide) due to protons in the water, superimposed on a very broad band (> 1,000 p.p.m.) due to protons on the starch. The measurements made all refer to the water line.

Table 1

Starch (per cent)	Line width (p.p.m.) Suspension	Gel
0	0·4 (pure water)	
8·2	0·45	0·45
15·0	0·45	0·61
25·8	0·43	1·06
25·8*	0·41	1·31
25·8†	0·45	0·68
40·1	1·35	1·12

* Wheat starch in 1 per cent sodium dodecyl sulphate.
† Waxy maize starch (100 per cent amylopectin) in water.
The remaining samples are wheat starch in water.

The suspensions containing up to 26 per cent starch showed a band of similar width to pure water, confirming the results of Shaw and Elsken[2].

However, on gelling there was a marked broadening which increased with increased starch concentration.

Broadening in this type of system could be due to three possible causes: (*a*) A decrease in the spin lattice relaxation time (T_1) as a result of an increase in the micro-viscosity of the water[5]. In gels this is generally of the same order as the viscosity of pure water, and must of course be distinguished from the bulk viscosity of the gel, which is very much higher than that of water. (*b*) Exchange between protons in liquid water and those in hydrate complexes, as proposed, for example, in octylamine–water mixtures[6] and in aqueous solutions of aluminium chloride[7]. (*c*) Exchange between water protons and starch hydroxyl protons.

In these mixtures the ratio of starch to water hydroxyl groups is too low to have much effect and the broadening is probably due largely to the extra binding of water into a four co-ordinated water lattice. This will increase the water line width due to factors (*a*) and (*b*). Pure water at 35° C. contains scarcely any molecules in this compact state; but there are several examples of hydrated macromolecules increasing the order of the water lattice[8], and in fact this explanation has been proposed to explain the broadening of the nuclear magnetic resonance water band in aqueous solutions of deoxyribonucleic acid[1].

The four co-ordinated water lattice is nucleated from water directly hydrogen bonded on to the starch hydroxyls and extends beyond the immediate neighbourhood of the starch. It is clear that the line width will increase with increased hydration, and hence it is not surprising that a broadening occurs on gelation. The broadening is greater in gels containing sodium dodecyl sulphate, which is known to increase starch swelling[9] at 80°.

The band-width depends partly on the amount of water which is bound into the more highly ordered lattice and also to some extent on the mobility of the macromolecule from which the water lattice is nucleated. In this connexion it is significant that the line width of a gel containing 26 per cent of waxy maize starch (100 per cent amylopectin) is considerably lower than that of the corresponding wheat starch gel. Waxy maize starch has less tendency to crystallize due to the higher proportion of branched-chain molecules. This will affect the line width in two opposing ways. Increased hydration will tend to broaden the water line, but this is more than offset by the increased mobility of the macromolecules.

The 40 per cent suspension, unlike the more dilute suspensions, gave a broader line than pure water. Presumably at this high concentration there are sufficient hydroxyls in the granules available for hydration to increase the structure of most of the water since there was no narrow 'free water' line superimposed on the broader line. On gelation there was actually a decrease in line width. This can be attributed to the increased mobility of the macromolecules in the gel, which is in agreement with results obtained from elasticity measurements[9].

In conclusion we can say that the width of the water line in starch gels and suspensions depends partly on the degree of hydration, which governs the number of molecules in a more highly ordered lattice than

normally prevails in pure water, and partly on the mobility of the macromolecules on which the water is solvated. At the lower starch concentrations the most important change on gelling is an increase in hydration due to the swelling of the granules. At the high concentration any effect on gelation due to increased hydration is more than offset by the increased mobility of the macromolecules, which causes a narrowing of the water band.

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The 'Irving–Williams' Order in the Metal-ligand Stretching Frequencies of Some Metal Hydrazine Complexes

MANY infra-red spectra of metal complexes have been examined in the 2–15μ region, but until now very few co-ordination compounds have been studied in the cæsium bromide region in which some metal-ligand atom-stretching frequencies are expected[1]. Furthermore, no correlation between the frequency of this vibration and the nature of the metal has been found[2].

We have measured the infra-red absorption spectra in the 15–35μ zone of the hydrazine complexes of the 3*d* sub-group metals of the general formula $M(N_2H_4)_2Cl_2$. The two bands in the 660–518 and 440–343 cm.$^{-1}$ regions have been assigned to the N_2H_4 rocking and to the *M*—N stretching vibrations, respectively. The sequence of these frequencies agrees closely with the 'Irving–Williams' order of the stability of bivalent metal complexes: manganese < iron < cobalt < nickel < copper > zinc (ref. 3).

In Table 1 the observed infra-red frequencies are recorded.

It is interesting to compare such frequencies with the strengths of the *M*—N bonds in complexes having four such co-ordinate links. As a measure of the bond energy, the heats of formation in aqueous solution of the *bis*-ethylenediamine metal ions, $M(en)_2^{2+}$ (ref. 4), have been used (Fig. 1). The *M*—N

Table 1. N_2H_4 ROCKING AND *M*—N STRETCHING FREQUENCIES FOR $M(N_2H_4)_2Cl_2$ COMPLEXES

Mn^{++}	Fe^{++}	Co^{++}	Ni^{++}	Cu^{++}	Zn^{++}		Type of vibration
518	554	582	613	660	580	cm.$^{-1}$	N_2H_4 rocking
343	369	388	409	440	385	cm.$^{-1}$	*M*—N stretching

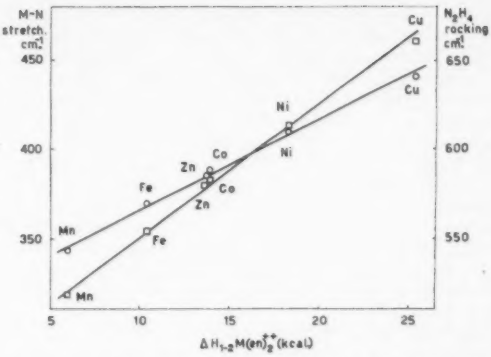

Fig. 1. Graph of the N_2H_4 rocking (□) and *M*—N stretching (○) frequencies versus the heats of formation of $M(en)_2^{2+}$ complex ions

stretching and the N_2H_4 rocking frequencies plotted against the ΔH_{1-2} values lie on two straight lines.

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Analogy to the Kirkendall Effect in the Gas Phase

THE Kirkendall effect[1] was first observed as a movement of fine molybdenum wire markers in a contact plane between brass and copper during interdiffusion. If diffusion occurs by a random walk movement of individual atoms, then, no matter what theory is employed for their detailed motion, it is difficult to see how it could produce movement of markers. Darken[2] considered that diffusion of copper and zinc occurred in opposite directions, at independent rates, and that the difference was compensated by a 'bulk flow'. If it fails to occur, voids are left behind by the more rapidly moving component, and this result of diffusion in metals has in fact been observed[3].

The concepts used by Darken were also developed by Hartley and Crank[4] for liquids, and their consequences have recently been studied in this Laboratory[5]. Lately, however, Adamson[6] failed to observe the Kirkendall effect in liquids, using colloidal particles as markers in sucrose solutions. Now, as Darken's concepts do not depend upon mechanism, they should be equally applicable to solids, liquids and gases[7], and we decided therefore to find if the Kirkendall effect could be demonstrated in gases.

A Loschmitt cell was used consisting of two glass cylinders (4 in. diameter, 7 in. length) which were sealed into two circular plane steel plates. By turning one plate over the other, the gases formed a diffusion boundary of sufficiently large area to make wall effects negligible. The gases used were CF_2Cl_2 and hydrogen, to give widely different diffusion-rates. As

marker, ammonium chloride smoke was used, formed by adding about 1 per cent hydrochloric acid to CF_2Cl_2 in the lower cylinder and 1 per cent ammonium to hydrogen. Fig. 1 shows photographs of the movement of the smoke, together with a stopwatch to indicate the elapsed time. It is considered that these provide evidence for the Kirkendall effect in gases. Hydrogen diffuses rapidly into the lower cylinder, and the resulting increase of pressure causes an upward bulk flow of the gas from this cylinder, carrying the smoke particles with it. The cloud does not move as a thin layer, since it consists of particles of various sizes which are settling under gravity. Some even fall almost at once into the lower cylinder and form a faint cloud there. In the following, only the movement of the finest particles at the top boundary of the cloud will be considered. No upward movement of a smoke formed at the boundary was observed when both cylinders contained CF_2Cl_2, with the same concentrations of hydrochloric acid and ammonia as before. A cloud formed in the lower cylinder as before due to larger particles falling rapidly, but the top of the cloud was sharp and settled with a slow, uniform velocity.

Some approximate calculations indicated that the rate of movement of the boundary was of the correct order. If the intrinsic diffusion coefficients of hydrogen and CF_2Cl_2, respectively, are denoted by D_A and D_B, Darken showed that, if N_A is the mole fraction of A in the boundary, and v is the rate at which the boundary is moved by bulk flow:

$$v = (D_A - D_B)\frac{\partial N_A}{\partial x}$$

For cylinders of infinite length:

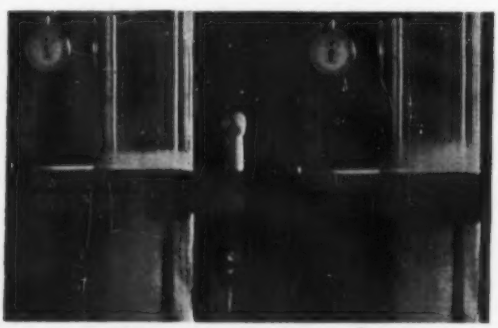
$$\frac{\partial N_A}{\partial x} = \frac{N_{OA}}{2}\cdot\frac{1}{\sqrt{\pi D_{AB} t}}$$

where N_{OA} = initial value of hydrogen = 1, and D_{AB} = interdiffusion coefficient.

Thus, if x_m equals shift of boundary in time t:

$$x_m = \int_0^t v\,dt = \frac{(D_A - D_B)}{\sqrt{\pi D_{AB}}}\cdot\sqrt{t}$$

The value of D_{AB} has been shown in this laboratory to be about 0·4 cm.²/sec., and it can readily be proved that, for this value, the assumption of infinite length for the cylinders is approximately valid up to $t = 200$ sec. Assuming that movement of the boundary is given by the surface of the smoke cloud,



a b

Fig. 1. Position of the smoke stream after 59 sec. (*a*) and 150 sec. (*b*)

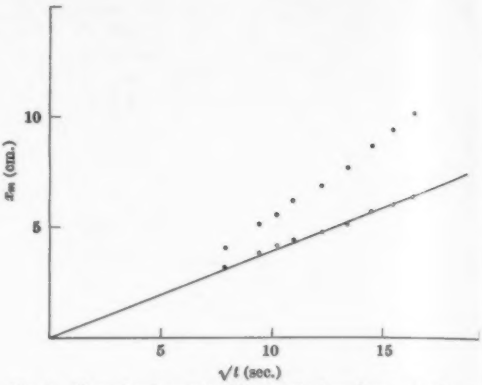


Fig. 2. Upward movement of the smoke boundary. ○, Uncorrected position; ●, corrected position

it can be seen in Fig. 2 that x_m versus $\sqrt{t}$ gives a reasonably straight line. From its gradient, a value of $(D_A - D_B) \simeq 0{\cdot}43$ was obtained. This is probably low, since the cloud was sedimenting. A correction was attempted by measuring the rate of sedimentation at the end of the experiment and using this to calculate the distance it would fall in time t. The corrected values in Fig. 2 show an upward curvature from a straight line, indicating an over-correction, as would be expected if particles were coarser when sedimentation was measured than when first formed in the early stages of a diffusion experiment. The gradient at the lower part of the corrected curve corresponds to $(D_A - D_B) \simeq 0{\cdot}63$.

Values of D_A and D_B have not been measured, but the self-diffusion coefficient for hydrogen is about 1·3 cm.²/sec. and a value of about 0·04 cm.²/sec. can be calculated for CF_2Cl_2 [5]. For gases, the intrinsic diffusion coefficient of a component equals its self-diffusion coefficient[7], and the difference of the self-diffusion coefficients of components in a 50 per cent mixture, corresponding to the diffusion boundary, should be about half the difference for the two pure gases, that is, about 0·7 cm.²/sec. Within the limitations of the experiment, therefore, the agreement is reasonably good.

Though the observed motion of smoke particles supports the concept of a bulk flow as part of an interdiffusion process, Waldmann[9] has put forward a theory for such motion which does not require the assumption of a bulk flow. Parameters to apply his equation quantitatively are not available, but it would seem that his effect should be of a similar order to that given by Darken's equation.

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A Model to account for the Production of Vibrationally Hot Molecules in Free-Radical Reactions

THE application of the flash photolysis technique to the study of the photodecomposition of molecules like ozone[1,2], nitrogen dioxide[3] and chlorine dioxide[3], by Norrish and co-workers, has revealed the occurrence of a very unusual series of reactions of the general type :

$$A + BCD \rightarrow (AB)^* + CD + \text{heat}$$

in which a large proportion of the heat of reaction remains concentrated as vibrational energy in the newly formed bond A—B. Table 1 summarizes the known reactions of this type, together with two apparently analogous reactions in which no vibrationally excited AB has been detected.

Table 1

Reaction	Excited molecule produced	Maximum energy of vibration (kcal./mole)
$O + ClO_2 \rightarrow O_2 + ClO$	O_2	34
$O + NO_2 \rightarrow O_2 + NO$	O_2	34
$O + O_3 \rightarrow O_2 + O_2$	O_2	63
$Cl + O_3 \rightarrow ClO + O_2$	ClO	12
$Br + O_3 \rightarrow BrO + O_2$	BrO	8
$H + O_3 \rightarrow HO + O_2$	HO	75
$I + NaI_2 \rightarrow NaI + Na$	NaI	?
$O + SO_2 \rightarrow SO + O_2$	none	—
$O + Cl_2O \rightarrow O_2 + Cl_2$	none	—

Up to the time of writing no model has been proposed which could be used either to correlate the experimental evidence tabulated above or to rationalize the 'abnormal' behaviour shown in such reactions[4]. This communication describes the development of such a model.

There are three points of similarity in all the reactions which yield vibrationally excited molecules ; it is always the newly formed molecule, AB, which is vibrationally excited ; the number of vibrational quanta possessed by AB is always far in excess of that 'allowed' by equipartition and Maxwell–Boltzmann energy distribution restrictions, so that clearly the collisions between the atom A and the molecule BCD must be of a specialized type ; the bond-strength B—C is moderate or weak.

In order to correlate these observations, a sequence of events may be suggested, as follows.

(1) The atom A approaches the terminal atom B with such a velocity that when A is finally brought to rest relative to B, the internuclear distance A—B is very short compared with the equilibrium distance in the molecule AB. This requires the existence of some attractive force to overcome the repulsion experienced by non-interacting particles in the systems to which the Maxwell–Boltzmann statistics and equipartition principles apply.

(2) The bond B—C must be weak relative to the newly formed bond A—B, so that the dissociation of the intermediate complex $(ABCD) \rightarrow AB + CD$ can occur easily, and so that little of the impact of A on B will be transmitted through to the bond C—D.

(3) In consequence, the final products of the 'encounter' will be a molecule AB produced initially in a highly compressed state, that is, vibrationally hot, and a molecule CD, produced vibrationally cold. The greater the attraction between A and B, and the weaker the bond strength B—C, the greater will be the proportion of the energy of reaction appearing in the new bond A—B.

Examination of Table 1 shows that in all the reactions which yield vibrationally hot molecules, the conditions implicit in the above scheme are operative, that is, attraction between A and B and weakness in the bond B—C.

In the first two reactions, both the atoms and the reactant molecules are paramagnetic, so that the probability of electron spin coupling will result in an attractive potential field between the atom and the molecule. The ClO—O and NO—O bond-strengths are both moderate, being about 60 and 72 kcal./mole, respectively.

The most striking feature of the next four reactions is the fact that they all involve the ozone molecule : it would be surprising indeed if this were fortuitous. It is at once obvious that ozone satisfies the requirement of a weak B—C bond, since the O_2—O bond dissociation energy is only 24 kcal./mole. However, since the molecule is diamagnetic it is not immediately obvious that there will be an attraction between the approaching atom and the terminal oxygen atom. In order to overcome this difficulty, it is convenient to consider the ozone molecule from a somewhat inverted point of view, that is, not as a strongly bound molecule in a singlet state, but rather as a weakly bound complex of a triplet oxygen molecule and a triplet oxygen atom. Although the complete system will have singlet multiplicity, at large O_2—O separations the terminal oxygen atom will assume in large measure the character of an unbound ^3P atom. This will be particularly favoured in ozone since the O_2—O bond-strength is so small, and, in consequence, the O_2—O vibrations have a large amplitude. Thus the formation of electron pair bonds between an approaching free atom and the terminal oxygen atom in ozone becomes a possibility ; as in NO_2 and ClO_2, this possibility will result in an attractive potential field between the approaching atom and the molecule. The well-known addition of ozone to olefins yielding covalently bound ozonides provides confirmation of its ability to form electron pair bonds.

The production of vibrationally excited sodium iodide following a collision between an iodine atom and a sodium molecule in the gas phase would be especially favoured, since not only is the Na—Na bond-strength extremely weak (17·5 kcal./mole), but also the coulombic attraction between the halogen atom and the alkali metal would be very strong indeed. This is consistent with the observation that sodium iodide is produced possessing nearly all the energy liberated in the reaction[5].

In the last two reactions tabulated, no vibrationally excited species are produced[6,7]. Again, this is consistent with the general scheme proposed, since both Cl_2O and SO_2 are diamagnetic, and at the same time the SO—O and Cl_2—O bond-strengths are large, being about 130 and 100 kcal./mole, respectively. (It will be necessary to break two Cl—O bonds in order to obtain the reaction $O + Cl_2O \rightarrow O_2 + Cl_2$, since in Cl_2O oxygen is the central atom.)

Summarizing, it is apparent that all the reactions tabulated can be understood in terms of the simple collisional model which has been proposed. The comparative rarity of reactions in which the products are vibrationally excited is consistent with the strict requirements necessary for such reactions. On the basis of the model, the reaction $O + ClCO \rightarrow ClO +$

CO should yield vibrationally excited ClO radicals, and experiments are being planned to determine whether or not vibrationally hot ClO is formed.

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Electrical and Magnetic Properties of β-Carotene Triiodide

Charge-transfer complexes formed between iodine and condensed ring aromatic hydrocarbons have been studied in some detail recently, most extensively by Akamatu, Inokuchi, Matsunaga and their co-workers[1]. We should like here to point out that iodine also reacts with β-carotene, a non-aromatic hydrocarbon containing eleven conjugated double bonds, to form a compound exhibiting electrical and magnetic properties similar to those of iodine-aromatic charge-transfer complexes. The stoichiometric formula of this compound is $C_{40}H_{56}I_3$; that is, it contains three iodine atoms per β-carotene molecule.

This material was prepared first by Arnaud[2] and later by Willstätter and Mieg[3] in the course of their investigations of the structure of carotene. It is formed by adding crystalline iodine to a concentrated solution of β-carotene in benzene or carbon disulphide. The triiodide, which is precipitated immediately, is washed with diethyl ether and dried in vacuum. The resulting powder has the same physical appearance (red by reflexion, green by transmission) and melting point (137° C.) as reported by Arnaud[2]. Iodine analyses were made on two samples, independently prepared, giving 41·1 and 42·9 per cent iodine (cal.: 41·5 per cent).

Evidently, the triiodide can be prepared only in the way outlined above. If one mixes solutions of iodine and β-carotene, only a slow reaction occurs giving a substance of formula $C_{40}H_{56}I_2$, presumably an iodine addition compound[3].

The samples of $C_{40}H_{56}I_3$ we have prepared all exhibit a strong electron spin resonance absorption consisting of a single line of Gaussian shape with $\Delta H_{p\text{-}p} = 11{\cdot}4$ gauss and $g = 2{\cdot}003$. A comparison of the electron spin resonance intensity of a freshly prepared sample with that of Coppinger's radical[4] indicates a spin density of $7\text{–}15 \times 10^{18}$ cm.$^{-3}$, corresponding to 0·01–0·02 spins per molecule of $C_{40}H_{56}I_3$. The electron spin resonance intensity and line shape show no dependence on temperature from −170° C. to +30° C. The signal intensity decays with time with a half-life of several days for a sample exposed to air; the half-life is several weeks for a sample prepared and stored under nitrogen.

The d.c. electrical conductivity of a powder sample was measured in a high-resistance powder press in which the sample could be compressed until its conductivity no longer increased with further compression. The sample and cell were reassembled several times; the conductivity in no case differed by more than 10 per cent. Fig. 1 illustrates the variation

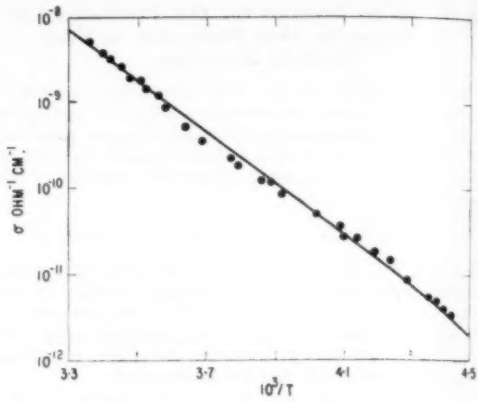

Fig. 1. Variation of electrical conductivity with temperature over the range $T = 225°$ K. to $T = 300°$ K.

of conductivity with temperature for a sample approximately 24 hr. old. A reasonable fit to these data is obtained using the expression $\sigma = \sigma_0 \exp(-E/kT)$, with $E = 0{\cdot}55 \pm 0{\cdot}5$ eV. and $\sigma\ (25°\text{ C.}) = 5 \times 10^{-9}$ ohm^{-1} cm.$^{-1}$. All the samples measured exhibit the same value of the quantity E, whereas the quantity σ_0 was observed to vary considerably from sample to sample. The conductivity decays slowly with time in a manner similar to the decay of the electron spin resonance signal intensity.

Conductivity measurements on powder samples, such as we present here, certainly are open to serious criticism[5]. However, we believe that these measurements have sufficient qualitative significance to establish the complete dissimilarity between the dependence on temperature of the conductivity and that of the electron spin resonance signal intensity in $C_{40}H_{56}I_3$. This result is in marked contrast to that of Singer and Kommandeur for the pyrene–iodine complex[6]. Our observations can be interpreted in two ways: either (1) the electron spin resonance intensity is not a measure of the number of carriers involved in conduction, or (2) the electron spin resonance intensity is a measure of the number of carriers involved in conduction, and since the intensity is independent of temperature, the dependence of the conductivity on temperature arises entirely from the temperature dependence of the carrier mobility.

We have also investigated the visible and ultraviolet spectra of dilute solutions of iodine and β-carotene in chloroform. Intense new bands appear at 2920 and 3600 Å. From a preliminary study of the spectra as a function of solute concentrations, it appears that both bands arise from a chemical species formed in a fairly rapid, reversible reaction between iodine and β-carotene, and that this species is most probably $C_{40}H_{56}I_2$. Unfortunately, this work is complicated by poor stability of the solutions. The bands at 2920 and 3600 Å. disappear in a matter of hours due, presumably, to the competing reaction in which the addition product $C_{40}H_{56}I_2$ is formed.

Dr. Edel Wasserman of the Bell Telephone Laboratories has undertaken a determination of the crystal structure of $C_{40}H_{56}I_3$ by X-ray diffraction[7]. This should clarify considerably the nature of the chemical bonding involved and should determine whether

this material can reasonably be described as a charge-transfer complex.

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BIOCHEMISTRY

Action of a Bacterial Dextranase on Branched Dextrans

SEVERAL mould species[1,2] and strains of Bacteroides[3] have been shown to secrete dextranases which hydrolyse, to different degrees, dextrans of various branched structures. Although glucose, *iso*maltose and *iso*maltotriose[1-3] have been shown to be among the main products of the hydrolysis, no oligosaccharides containing the glucosidic branch linkages have so far been identified in the enzyme hydrolysates. Recently, several rumen strains of an organism, closely resembling *Lactobacillus bifidus*[4], were found to secrete a dextranase which hydrolysed an unbranched *Streptococcus bovis*[5] dextran to a mixture of *iso*malto-triose, -tetraose, -pentaose and -hexaose[6]. The enzyme also hydrolysed a dextran (produced by *Leuconostoc mesenteroides*, Birmingham strain) containing 12–15 per cent of α-1,3-branch links[7] to a mixture of tri- and higher saccharides, which were not examined further. We have now investigated the oligosaccharide mixture produced by the enzyme from this and other branched dextrans.

Solutions were prepared containing dextranase[6] (10 mgm.), purified[7] dextran (30 mgm.), and citrate buffer (0·2 *M*, *p*H 5·5, 5 ml.). A solution of the above composition, containing unbranched *S. bovis* dextran, was used as a control. The solutions were incubated under toluene at 37° C. for 36 hr., after which time there was no further increase in reducing sugars. The final digests were desalted with 'Biodeminrolite', concentrated under reduced pressure to a small volume, and analysed by paper chromatography using the ethyl acetate, pyridine, acetone, water solvent of Malpress and Hytton[8]. Reducing sugars were located with silver nitrate[9]. Intense spots, corresponding to *iso*malto-triose, -tetraose and -pentaose, were present on chromatograms of all the hydrolysed dextrans. In addition, chromatograms of the *Leuconostoc* branched dextran digest showed two minor reducing components moving just in front of *iso*malto-tetraose and -pentaose respectively. These chromatograms also revealed a mass of unresolvable reducing components, $R_G <$ *iso*maltopentaose, which was absent from the control digest. Portions of the two extra oligosaccharides were eluted and hydrolysed in *N* sulphuric acid for 4 hr. at 100° C. The hydrolysates contained a single component which was chromatographically identical to glucose.

Table 1. POSSIBLE OLIGOSACCHARIDES IN ADDITION TO *iso*MALTOTRIOSE— -PENTAOSE DETECTED IN DEXTRANASE–DEXTRAN DIGESTS

Dextran; organism and type of branch link	Fast-moving tetraose	Fast-moving pentaose	Saccharides of $Rg <$ *iso*maltopentaose
(1) *S. bovis*; unbranched (ref. 5)	absent	absent	*iso*malto-hexaose^{+++}, -heptaose^{++}
(2) *L. mesenteroides* (Birmingham); modified, 2 per cent α-1,3- (ref. 9)	trace	trace	*iso*malto-hexaose^{++}, -heptaose^{+}
(3) *L. mesenteroides* (Birmingham); 12–15 per cent α-1,3- (ref. 7)	++	+++	Intense unresolved mixture $Rg <$ *iso*maltopentaose
(4) *L. mesenteroides* (N.R.R.L. *B*512); 5 per cent α-1,3- (ref. 10)	trace	trace	possible hexaose^{+++}, heptaose^{+++}, octaose^{++}
(5) *Betabacterium vermiforme*; 5 per cent α-1,3-, 5 per cent α-1,4- (ref. 11)	trace	trace	possible hexaose^{+++}, heptaose^{+++}, octaose^{++}
(6) *Acetobacter capsulatum*; 10 per cent α-1,4- (ref. 12)	absent	absent	possible hexaose^{+++}, heptaose^{+++}, octaose^{++}, nonaose^{+} and unresolved higher saccharides

Gradings allocated on the basis: trace, just visible; +, clearly visible; +++, definite black spot. Under the conditions used *iso*maltotriose spot = ++++++.

The three main components in the digest have been shown, by movement in five solvent systems and reaction with four spray reagents, to be chromatographically identical with *iso*malto-triose, -tetraose and -pentaose, respectively. It seems likely, therefore, that the two extra saccharides contain, in addition to α-1,6-links, the α-1,3-branch links of the original dextran. Their absence from the control digests seems to rule out the possibility that they were formed by an enzymic transferase action on the *iso*maltodextrins produced in the digests. Attempts are now being made to elucidate the structure of these two sugars. As the dextranase has been shown to hydrolyse *iso*malto-heptaose and -octaose, the mass of higher saccharides present in the branched dextran digest probably also contains α-1,3-branch links which prevented their further hydrolysis. Two acid-degraded specimens of the branched *Leuconostoc* dextran, mol. wt. 300,000 and plasma grade, were also treated with dextranase. The same two extra saccharides were detected on chromatograms of the digests at possibly lower concentrations. The three *iso*maltodextrins and the unresolved mixture of $R_G <$ *iso*maltopentaose were also present.

Several other dextrans, the structures of which have been examined by chemical methods, were treated with the dextranase and the hydrolysates examined by paper chromatography. The results, with those already obtained, are listed in Table 1.

It appears that *L. bifidus* dextranase is unable to cleave branching links in dextrans. This is not surprising as the organism was cultured in a medium containing unbranched *S. bovis* dextran. The mixture of saccharides produced seems to depend not only on the type of branching, but also on the degree of branching; compare dextrans Nos. 3 and 4 in which there appears to be a definite difference in the composition of the saccharide mixture of $R_G <$ *iso*maltopentaose. Another dextran, produced by *L. mesenteroides* (N.R.R.L., *B*742) and containing 36 per cent of α-1,3- and α-1,4-links[11], was also treated with the enzyme. This dextran was not hydrolysed by the dextranase, a result which is in agreement with the markedly different serological properties reported[13] for a similarly branched dextran produced

by another strain (N.R.R.L.-*B*742-*LR*) of this organism. The possibility that dextranases produced by *L. bifidus* and other organisms may be of help in establishing the structures of dextrans is being investigated further.

This work was carried out as part of a programme of research supported by the Department of Scientific and Industrial Research and directed by Prof. E. J. Bourne. Thanks are due to Dr. A. E. James, of Glaxo, Ltd. (Barnard Castle), for the gift of the samples of degraded *Leuconostoc* dextran.

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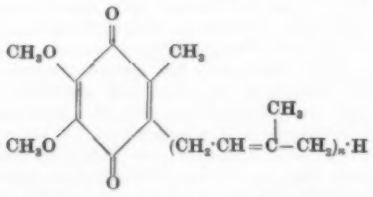
Ubiquinones and Ubichromenols in the Rat

Ubiquinone, a naturally occurring quinone of considerable biological interest, was first isolated by Morton *et al.*[1], who found it in many kinds of animal tissue. Lester *et al.*[2] have shown that a series of such quinones exist, and have isolated, from different organisms, five compounds of general formula :



differing from each other by single isoprene units (n = 10, 9, 8, 7 and 6). Further studies[3] suggested that ubiquinone 50 (n = 10) was the normal quinone in higher mammals, but Rüegg *et al.*[4] have recently shown that rat liver contains ubiquinone 45 (n = 9).

By the use of analytical procedures described elsewhere[5], we have now found that the ubiquinone fraction of rat tissues may contain up to six substances. These are the isoprenologues, ubiquinones 50, 45, 40 and 35 and two other quinones, one of which has been tentatively identified as dihydroubiquinone 45 (side-chain reduced), whereas the second is an unsaturated substance of greater molecular weight than ubiquinone 50, and possessing a distinctive ultra-violet spectrum with sharp absorption peaks at 252·5, 259, 267·5 and 271·5 mμ.

The six substances do not usually occur together. Rather, two distinct patterns are found. One, in which only ubiquinones 45, 40 and 35 are present, has so far only been found in the tissues of older rats, more than 12 months of age. The second pattern, in which all or some of the other three compounds occur together with ubiquinone 45, is always observed in younger animals and sometimes in the older ones. In most of the 14 tissues so far studied, ubiquinone 45 is the predominant quinone. Although we do not yet understand the significance of the two quinone patterns, it seems that (at least in rats of our Norwegian hooded strain) they only vary in a quantitative manner from organ to organ. Thus we have never observed ubiquinone 50 in the same pattern as ubiquinone 40 in the tissues of our animals. There may, however, be strain differences, since in rats of another strain, we have seen an occasional mixed pattern containing five quinones (including the unidentified quinone referred to above). Our investigations of the quantitative relationships and the influence of dietary and other factors on these quinone patterns will be reported elsewhere.

The discrepancy between the melting points given by Lester *et al.*[2] for ubiquinones 50 and 45 (49·9° and 45·2°, respectively) and those given by Morton *et al.*[1] for specimens isolated from "different sources" is still unresolved, and it has been suggested[6] that the preparations of Morton *et al.* contained artefacts caused by replacement of methoxyl by ethoxyl groups during the preliminary purification with ethanolic alkali. However, in view of our present findings, it seems possible that, since Morton *et al.* used rat liver as one of their sources, their melting-point data may be sufficiently explained by the likelihood that they were dealing with mixtures.

The recent demonstration by Laidman *et al.*[7] that substance *SC* is a cyclic isomer of ubiquinone 50 (which they have called ubichromenol) suggests a biochemical relationship between the two compounds. We have now found that the mixture of ubiquinones in rat tissues is almost invariably accompanied by a similar mixture of ubichromenols, although—because of chromatographic and identification difficulties—it is not always possible to detect the completely corresponding series. So far, we have tentatively identified ubichromenols 50, 45, 40 and 35 and observed that these substances are only normally present if the preparation contains the corresponding isomeric quinone or mixture of quinones. Thus ubichromenol 50 is not found in preparations that contain the 45–40–35 pattern of quinones. Ubichromenol 45 is usually the main chromenol present, but the patterns can be varied under suitable experimental conditions (these are at present under study).

The ubiquinones were identified by their spectra and paper chromatographic behaviour in comparison with known markers. The ubichromenols and dihydroubiquinone 45 were characterized by their spectra and also their chromatographic behaviour, followed by calculation of R_M values from a series of parameters obtained from model compounds. Dihydroubiquinone 45 was also converted to perhydroubiquinone 45 for identification purposes.

These findings suggest that ubiquinones and ubichromenols may be synthetically connected in biological systems, perhaps through intermediary dihydroquinones. Further work (to be published) confirms this concept and has demonstrated that the

synthesis of ubiquinone is, contrary to the findings of other workers[8,9], significantly affected by vitamin E.

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Identification of Isomeric Chondroitin Sulphates

Chondroitin sulphate occurs in three isomeric forms, *A*, *B* and *C* (see review by Hoffman *et al.*[1]). Mathews[2] has recently found the *pK* values of the carboxyl groups of chondroitin sulphate *A* and chondroitin sulphate *B* to be 3·1 and 3·5–3·6 respectively. In addition the *A* and *B* isomers have very similar electrophoretic mobilities in free solution at *p*H values of 2, 3 and 7. Results for chondroitin sulphate *C* were not given.

This communication describes the results of experiments on the ionophoretic behaviour of the three compounds on paper. Using buffers of varying compositions and *p*H (*p*H 2·3, 5·5, 6·0, 9·0 and 9·5), chondroitin sulphate *C* was found to have a consistently lower mobility of 0·9 times that of either *A* or *B* isomeric forms. The latter was found to have the same mobilities in all the buffers used. Analyses of the chondroitin sulphate *A* and chondroitin sulphate *C* used in these experiments have been reported previously; they contained negligible amounts of protein (0·5 per cent)[3]. Additional preparations of the *A* form were made from bovine nasal septum and were found to have identical ionophoretic mobilities to that isolated from bovine trachea. The *B* form was kindly supplied by Dr. A. Dorfman. When mixtures of the isomers were subjected to ionophoresis, resolution could not be obtained (Fig. 1). Extension of the path of migration from 20 cm. to 28 cm. did not facilitate the separation of mixtures. Depolymerization of chondroitin sulphate *C* by a very brief treatment with testicular hyaluronidase[3] did not alter its mobility relative to chondroitin sulphate *A*. Similar results were obtained when either the sodium or the calcium salts of the *A* and *C* isomers were used. It seems likely that the difference in ionophoretic mobility between the *A* and *C* isomers is related to the position and conformation of the sulphate group. This group is axial in *A* and equatorial in *C*[4].

It has been shown previously that forms *A* and *C* can be synthesized by a cell-free extract of embryonic chick cartilage[5]. The extract is relatively saturated with chondroitin sulphate *A* and little effect on the

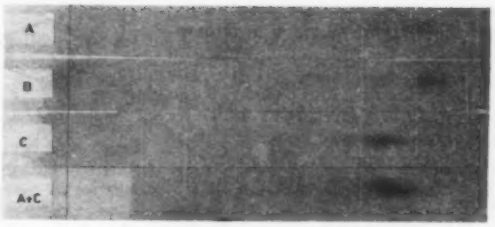


Fig. 1. Paper ionophoresis of chondroitin sulphate *A* (*A*), chondroitin sulphate *B* (*B*), chondroitin sulphate *C* (*C*) and a mixture of isomers *A* and *C* in 0·05 *M* sodium phosphate, *p*H 6·0, at 9·7 V./cm. for 4·5 hr. 2·5 μl. of a 3 per cent w/v solution of each isomer applied to dry paper (Schleicher and Schull 2043*B*). Stained with toluidine blue

incorporation of (sulphur-35) sulphate into chondroitin sulphate resulted when the *A* isomer was added to this extract and the mixture incubated with adenosine triphosphate and (sulphur-35) sulphate. Addition of the *C* isomer, however, caused a marked stimulation of incorporation of sulphate into chondroitin sulphate. A type-specific priming mechanism was evident. By removal of the normal content of acid mucopolysaccharides from the chick cartilage extract by treatment with protamine, the ability to synthesize chondroitin sulphate was lost but was restored by addition of the *A* or *C* forms. Chondroitin sulphate *B*, which does not occur in cartilage[6], could not replace the *A* or *C* isomers but did show some priming power which was perhaps due to small amounts of the *A* or *C* isomers possibly contained in the preparation. Addition of *A* or *C* isomers to the enzyme system treated with protamine should result in synthesis of the corresponding isomer if the type-specific mechanism of priming action is correct[3]. Since the pure isomers *A* and *C* of chondroitin sulphate have different ionophoretic mobilities, it is possible to test this theory. Results of such an experiment are shown in Fig. 2. The (sulphur-35) chond-

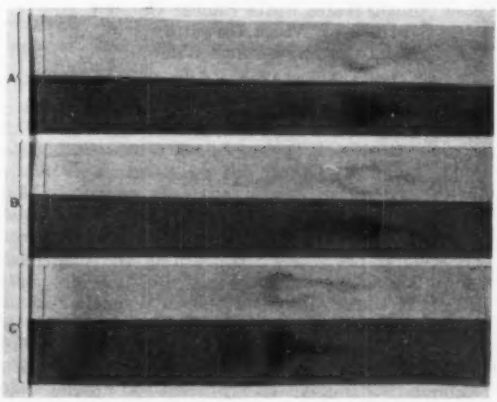
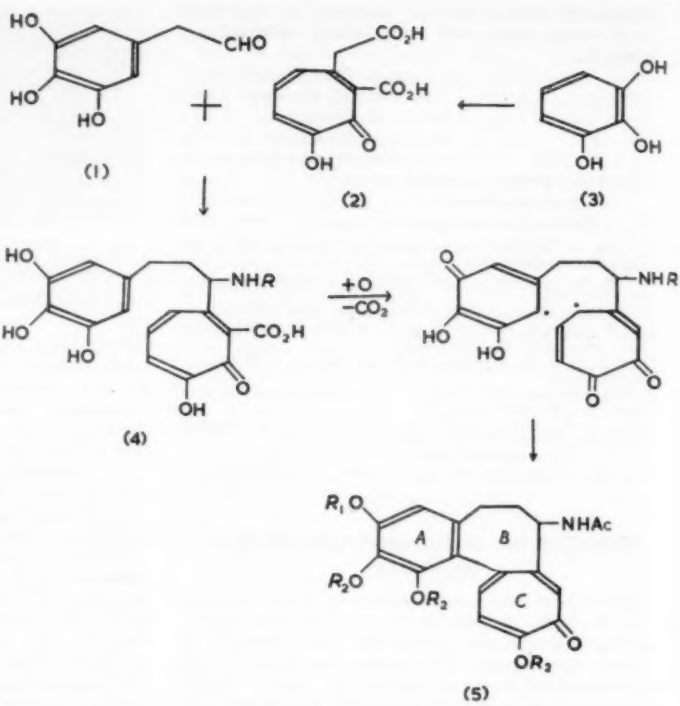


Fig. 2. Shows the ionophoretograms and the corresponding radioautographs obtained with the chondroitin sulphate isolated from normal incubations (ref. 3) in the presence of 10 μc. (sulphur-35) sodium sulphate, 0·4 ml. of protamine-treated chick cartilage extract and 2·1 mgm. of the sodium salts of each chondroitin sulphate isomer. After incubation, the tubes were heated at 100° for 1 min., cooled, centrifuged and the chondroitin sulphate isolated by precipitation with 'Cetavlon' in the presence of sodium sulphate. Each sample was dissolved in 0·5 ml. of 10 per cent w/v sodium chloride and the free chondroitin sulphate precipitated by the addition of alcohol (1·5 vol.). The precipitate was dissolved in 0·1 ml. of water and 10 μl. applied to paper for ionophoresis in 0·025 *M* citrate buffer, *p*H 5·5, at 9·7 V./cm. for 4 hr. The metachromatic zones are more diffuse as compared with Fig. 1, due to the larger amounts of material applied to the paper

roitin sulphate isomer synthesized by the enzyme extract is demonstrated by the radioautographs and these zones correspond to the isomer added to, and isolated from, the incubation mixture as shown by the metachromatic zones. This is conclusive proof for the specificity of the enzyme–substrate relationship.

One consequence of these results is applicable to the study of the types of chondroitin sulphates being actively formed by particular tissues. Rather than attempting to isolate, fractionate and identify the chondroitin sulphates from the relatively large amount of tissue normally required by this procedure, it should be possible to prepare an enzyme extract from small amounts of such tissue, free it of its constituent acid mucopolysaccharides and determine which type or types of chondroitin sulphate are synthesized by observing the effects of addition of the three isomers. Alternatively, to determine whether isomer *A* and/or *C* is synthesized, a crude preparation of the constituent acid mucopolysaccharides can be isolated from the tissue in question and tested with the embryonic chick cartilage extract in the presence and absence of excess amounts of the *A* and *C* isomers. It is intended to apply this type of investigation to the study of stromal elements associated with certain tumours.



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Biosynthesis of Colchicine

Of several proposals[1–4] concerning the biogenesis of the alkaloid colchicine (5; $R_1 = R_2 = Me$), only that of Wenkert[4] involves the intervention of an intact tropolone ring prior to formation of ring *B*.

I now wish to suggest that a radical pairing reaction (4→5) involving one-electron oxidation of a tropolone ring might well represent the crucial stage in the elaboration of the tricyclic system. In support of this view I may mention that radical substitution has been observed in the case of diazotized 5-aminotropolone[5]. Also, the occurrence of partially methylated alkaloids[6,7] in *Colchicum* species (for example, 5; $R_1 = H$; $R_2 = Me$) and the unlikely intervention of the C_6—C_1→C_7 change at aromatic level[4,8] would seem to be in accord with the present proposal.

It may also be conceivable that the genesis of purpurogallin from pyrogallol[9] involves a radical-pairing reaction[9]. The conversion of the former compound to the acid (2) takes place under biochemically acceptable conditions[10]. The biosynthesis of (4) has many possibilities of which only one is suggested herein. Experimental confirmation of this concept is being sought.

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Swelling of Fresh and Aged Liver Mitochondria as affected by Succinate, Adenine Nucleotides and Thyroxine

It has been observed previously[1] that isolated mitochondria from primary and transplanted hepatocellular hepatomas, in contrast to their normal counterparts from liver, do not swell to any marked extent in the presence of thyroxine. The increasing evidence[2–4] that both the spontaneous and thyroxine-induced swelling of liver mitochondria is actually dependent upon respiration (that is, when no oxidizable substrate is added, upon endogenous substrate and co-enzymes) has led us to re-examine the

effect of thyroxine on the swelling of the tumour particles now incubated in the presence of succinate.

Previous investigators[2,5] reported that several oxidizable substrates, including succinate, markedly and instantaneously accelerated the swelling of fresh liver mitochondria from the rat. However, in our control experiments carried out with freshly isolated (0·3 *M* sucrose) mouse and rat liver mitochondria under similar conditions[2,3], the latter effect, as far as succinate (5×10^{-4} *M*) was concerned, has never been observed. On the contrary, in the suspensions (0·3 *M* sucrose containing 0·02 *M tris* (2-amino-2-hydroxymethylpropane-1 : 3-diol chloride), *p*H 7·4, 22 ± 1° C.) in which spontaneous swelling occurred, succinate prevented the latter completely during at least 40 min. Hereafter the protection changed into a sudden acceleration of the swelling so that in a relatively short time (approximately 20 min.) a decrease of 50 or more per cent in the $O.D._{520}$ ($O.D._{520}$, optical density at 520 mμ) took place. In addition to recording the decreases in $O.D._{520}$ as a measure of swelling, mitochondrial samples were examined under the phase contrast microscope and the fall in $O.D._{520}$ was always found to be accompanied by the typical signs of swelling. Obviously, then, in our hands the swelling of the liver mitochondria in the presence of succinate was conditioned by some 'change' occurring during the incubation at room temperature.

Since direct and indirect evidence[6–8] shows that phosphorylating or mitochondria containing adenosine triphosphate do not swell, it was thought likely, in view of the absence of magnesium and adenine nucleotides from the medium, that the above 'change' was related to the abolition (of one of the intermediate reactions[9]) of oxidative phosphorylation, perhaps as a result of the loss of endogenous adenine nucleotides. If this consideration contained an element of truth, the alleged change might be accelerated by subjecting the mitochondria to ageing[10] and, as long as it was not irreversible, counteracted by the addition of adenine nucleotides in a sufficiently low concentration (10^{-5} *M*) as to make any chelating effect of the latter unlikely. Keeping the mitochondria during 3 hr. at 0° C. in 0·3 *M* sucrose reduced the time of protection afforded by succinate against the spontaneous swelling on subsequent incubation in the 0·3 *M* sucrose–0·02 *M tris* medium to about half the value found for the fresh particles. The outburst of swelling which then set in, and also the later one occurring in the fresh preparations, could be prevented (or at least markedly delayed) by the simultaneous presence of adenosine monophosphate and adenosine triphosphate (10^{-5} *M* each). When, following the 3 hr. at 0° C., the mitochondria had in addition been held in 0·3 *M* sucrose at 37° C. during 10–15 min., succinate momentarily accelerated the swelling and the adenine nucleotides showed scarcely, if any, retarding effect on the latter process. The effects of succinate under the various experimental conditions were always abolished by malonate (10^{-3} *M*), pointing to the paramount role of succinate oxidation in the two kinds of effects, that is, the protection against and the acceleration of swelling.

If, as has been suggested[11,12], the induction of swelling by thyroxine *in vitro* represents an acceleration of a process which the particles are already inherently capable of undergoing spontaneously, it must be possible to counteract the thyroxine-induced swelling by addition of succinate and the adenine nucleotides. The onset of the swelling produced by thyroxine (3×10^{-6} *M*) in fresh mitochondria was indeed significantly delayed (10–15 min.) by succinate and still more by succinate and adenosine monophosphate and adenosine triphosphate (at least another 10 min.). Malonate, again, prevented this effect of succinate. The retardation of the onset of the thyroxine-induced swelling produced by succinate alone or together with the nucleotides was somewhat less pronounced in the suspensions which had been previously kept at 0° C. during 3 hr., but was completely missing in those preparations which had received another incubation at 37° C. during 10–15 min. In fact, the swelling produced by thyroxine in the latter preparations was frequently (not always) largely dependent upon the presence of succinate, which might have been due to the limiting amount of endogenous substrate still present[3]. By contrast, in the fresh and mildly aged mitochondria the extent of swelling ultimately reached in the presence of thyroxine (50 per cent decrease in $O.D._{520}$) was independent of the additions made. In view of the present observations it is of interest that Kaufman and Kaplan[13] have recently reported that, in contrast to the finding of previous investigators[3,14], succinate also inhibited the phosphate-induced swelling of the mitochondria.

The rats and mice used in the above experiments were fed *ad libitum* with the standard laboratory diet. Starvation during 24 hr. prior to the preparation of the mitochondria did not change the results. Rats which had been fed polished rice during several months yielded liver mitochondria of which the onset of swelling on incubation with thyroxine was very markedly retarded by succinate and by succinate plus the nucleotides, sometimes even for 40 and 60 min., respectively.

On account of all criteria set out above, freshly isolated liver mitochondria from rats, which had received an intravenous injection of a hepatoxic dose of the hepatocarcinogen dimethylnitrosamine (100 mgm./kgm. body-weight) 20 hr. earlier, have been found to resemble closely liver mitochondria from normal rats previously aged during 3 hr. at 0° C. followed by 15 min. at 37° C.

In view of the 'change' which has been postulated above as conditioning the swelling of mitochondria, it is of interest that the liver mitochondria from the dimethylnitrosamine-treated animals showed a partly uncoupled oxidative phosphorylation and an increase in adenosine triphosphatase activity, the manifestation of which was for the greater part dependent on magnesium. In the swelling experiments with normal liver mitochondria (fresh or after 3 hr. at 0° C.) several cases have been encountered in which adenosine monophosphate and adenosine triphosphate added in the absence of oxidizable substrate had scarcely, if any, effect on the patterns of the spontaneous and thyroxine-induced swelling (especially in suspensions containing mitochondria which had been kept at 0° C. during 3 hr.), or a smaller effect than when added in conjunction with succinate.

It may therefore be concluded that the process which prevented the entry of water into the mitochondria was dependent upon added oxidizable substrate and adenine nucleotides (as distinct from the situation in which a high concentration of adenosine triphosphate added singly may prevent or

reverse swelling[9,14]), thus pointing to a role of oxidative phosphorylation[7,8] in the maintenance of mitochondrial structure. As regards the nature of the substrate, it appeared that succinate was (much) more effective than glutamate, α-ketoglutarate, pyruvate or β-hydroxybutyrate in counteracting the spontaneous and thyroxine-induced swelling.

Glutamate may, in fact, cause an immediate swelling of the fresh particles, especially when diphosphopyridine nucleotide was also present; diphosphopyridine nucleotide (3×10^{-4} *M*) alone was sometimes similarly active[4].

The difference in effect of the various substrates might have been due to the fact that the phosphorylation accompanying succinate oxidation, or an intermediate reaction thereof, is especially involved in the contraction of the mitochondrial membranes[7] and/or to the fact that the corresponding processes of the diphosphopyridine nucleotide-linked oxidations are less stable[15], so that in the latter case the postulated 'change' may occur more readily under the conditions of the present experiments, which are certainly unfavourable to the maintenance of these integrated systems. It appears that the 'change' sets the trigger for swelling, while the actual swelling is dependent upon the presence of substrate, that is, on electron transport in (part of) the respiratory chain[2,3].

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Presence of Protein in Some Serum Filtrates

In the determination of creatinine in plasma or serum the method of preparation of protein-free filtrates is known[1] to influence the total chromogen content of such fluids. Moreover, varying amounts of non-creatinine chromogen in such filtrates are known[2] to be partly responsible for differences in the total chromogen content.

It is generally assumed that a 1 : 5 'neutral' tungstic acid filtrate (pH > 2·5), prepared as follows: 6 ml. distilled water, 2 ml. serum, 1 ml. 10 per cent sodium tungstate, 1 ml. 0·66 *N* sulphuric acid, and filtered through a Whatman No. 1 filter paper, is totally free of protein. Yet, it is well known that the precipitation of proteins by tungstic acid and other 'protein precipitants' consists of a series of changes in the protein molecule, which may, under certain conditions, be reversible. For it often happens that more than one denatured protein is formed by the action of these protein precipitants on a solution containing different amounts of albumins and globulins. Moreover, the isoelectric points of these proteins are different, so that a certain proportion of the metaprotein so formed may remain in solution at any given reaction. Further, these changes often consist in the opening up and extension of the highly organized coiled polypeptide chains of the native proteins which effect their viscosity, particle-size and solubility, etc.

Thus, a 'neutral' tungstate filtrate contains a small amount of protein (3·08 mgm./100 ml. serum) which can be precipitated by 5 per cent phosphotungstic acid in 2 *N* hydrochloric acid (1 ml. to 5 ml. filtrate). A 1 : 10 tungstate filtrate, prepared as follows: 7 ml. distilled water, 1 ml. serum, 1 ml. 10 per cent sodium tungstate and 1 ml. 0·66 *N* sulphuric acid, contains no such detectable protein. It is evident, therefore, that a 1 : 5 'neutral' filtrate is not entirely 'protein-free' but contains some material which has escaped total precipitation or has been held in solution under the conditions of precipitation. Further, it is possible that other low molecular weight carbohydrate-containing proteins, particularly the mucopolysaccharides, may also be present in plasma or serum filtrates, as some of the acid mucopolysaccharides have a very acid isoelectric point.

The protein precipitated by phosphotungstic acid has a concentration of 0·08 mgm./100 ml. serum (in terms of creatinine) in normal pooled sera. Moreover, since protein is 'chromogenic' to alkaline picrate solution, it is possible that some filtrates may contain small amounts of protein which may be related to the so-called 'interfering material' (non-creatinine chromogen) in the determination of creatinine by the Jaffé reaction in biological fluids. For this figure is in fairly good agreement with that found by Owen, Iggo, Scandrett and Stewart[3] using the *NC*-creatinine destroying bacteria of Miller and Dubos[4] for a 'neutral' tungstate filtrate (1 : 5). Further, Lloyd's reagent, which is used to remove the 'interfering material' from a serum filtrate[3], is also widely used for removing proteins at a pH 2·0–3·0 from protein-containing solutions.

Thus, it should be remembered that the various protein precipitants differ in their ability to produce a plasma or serum filtrate which is completely free of protein, and of low molecular weight protein fragments (proteoses and peptones, etc.) which can react and interfere with the Jaffé reaction.

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PHYSIOLOGY

Endocrine Control of Sexual Reproduction in *Opalina ranarum* Parasitic in *Rana temporaria*

It is well known that opalinids parasitizing the recta of Amphibia multiply asexually by binary fission during most of the year. During the breeding season, however, the reproductive pattern changes to a sexual one, the preliminary stages of which are marked by an increase in the multiplication-rate and the production of small forms and minute individuals. The latter eventually encyst and are passed out with the fæces of the frog. If ingested by tadpoles, they excyst, form micro- and macro-gametes, and the resulting zygotes give rise to the multinucleated opalinids in the newly metamorphosed frogs.

It has long been suspected that the stimulus for inducing the change in the reproductive pattern of the opalinids was related to the endocrine behaviour of the host. Bieniarz[1] found that when male *Rana esculenta* were given injections of human pregnancy urine, the opalinids changed to a sexual pattern of reproduction resulting in the production of cysts. He suggested that the change might be initiated by the human chorionic gonadotrophin present. Cehovic[2] injected *R. esculenta* and *R. temporaria* with pregnancy urine, chorionic gonadotrophin or frog pituitaries, and obtained cyst formation. He concluded that the correlation between host and parasite life-cycles was due to pituitary activity and probably due to the production of gonadotrophin.

We have recently carried out a series of experiments on normal, hypophysectomized and gonadectomized *R. temporaria* with the following results.

(*a*) Injection of œstrone or gonadotrophic substances (concentrated or untreated pregnancy urine, chorionic gonadotrophin, serum gonadotrophin, suspension of frog hypophyses) to male and female frogs induced the sexual reproduction pattern of development in the opalinids—as evidenced by cyst production—but only in the period just prior to the breeding season (that is, during November–February in Europe) and not at other times of the year.

(*b*) Testosterone propionate and adrenaline injected into male and female frogs induced the sexual cycle of reproduction in the parasites during any time of the year.

(*c*) In gonadectomized animals, only injections of testosterone propionate were effective in inducing the sexual reproductive cycle in the parasites; adrenalin was ineffective.

(*d*) *In vitro*, gonadotrophic hormones gave negative results in all cases; but some positive results were obtained with untreated pregnancy urine. Some cultures treated with œstrone or hydrosoluble testis extract produced dividing stages and small forms, but cysts were never produced.

(*e*) In frogs prevented from copulating, the sexual reproductive cycle of the opalinids occurred in female frogs 77 days later than those which had copulated, and in the males, 82 days later.

These results clearly suggest that the induction of a sexual reproductive pattern in the opalinids is related, not to the levels of gonadotrophic hormones, but to the levels of gonadal hormones present in the host. In the male frog, the evidence shows that testosterone is implicated. In the female frog, in which the origin and nature of the gonadal hormone are obscure[3], the situation is not clear, for œstrone has been found only to induce cyst formation during the period just prior to the breeding season.

There is no evidence, as yet, to indicate whether the gonadal hormones exert their effect on these Protozoa directly or whether it is their breakdown products which are involved, or whether either of these exert their effect indirectly through some other aspect of the host's metabolism.

The effects of adrenalin injections in Amphibia are complex[4,5], and its action in inducing sexual reproduction in opalinids during any time of the year cannot be simply explained at the present phase of this work. The fact that it failed to induce cyst formation in gonadectomized frogs suggests that its action in some way induces the release of sex hormones, even when, in the male outside the breeding season, interstitial cells are absent from the testes.

Just prior to the breeding season, keeping the frogs at 8–12° C. induced cyst formation. That this result is attributable to the induction of early sexual maturity in the host and the subsequent release of the gonadal hormones may be shown by the fact that, during the summer, maintaining frogs at 20° C. failed to induce cyst formation, although injections of testosterone propionate induced the sexual cycle in the Protozoa, as at other times of the year.

Dr. Elspeth McConnachie[6] has kindly sent us the text of manuscript (in the press) in which she describes the induction of cyst production in *Opalina* by injection of frogs with chorionic gonadotrophin and frog pituitary extract. Although no experiments were carried out with the gonadal hormones, she concludes on theoretical grounds that the factors provoking encystation are probably the gonadal hormones.

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Dipeptidase Activity of Brain

Available knowledge on the dipeptidase activity of brain is limited to the enzymatic hydrolysis of DL-alanyl-glycine[1–3]. Detailed studies by Pope *et al.* have dealt with the intralaminar distribution of dipeptidase activity towards DL-alanyl-glycine in the cerebral cortex of rat[1,2] and man[3]. Our own studies on proteolytic activity of brain led to a systematic inquiry into the existence of any selective or preferential dipeptidase activity of brain towards any particular dipeptidase structure. The present preliminary report deals with the systematic quantitative differences observed in the hydrolysis of the series of N-glycyl-dipeptides by mouse brain.

Freshly removed brains of adult Swiss albino mice were frozen on a glass slide placed on dry-ice, and immediately trimmed with a razor to remove the

olfactory pole and the occipital poles (at the superior collicular level) to yield a standard-size block which was then cut into frontal sections of 75μ thickness on a freezing-microtome. Alternate sections were collected for total dry weight. Sections were immediately transferred to a chilled weighing-bottle containing 30 per cent glycerol in 4 per cent phosphate buffer at *p*H 6·97, and extracted overnight at 2° C. with occasional gentle stirring. This extraction procedure, similar to that used by Pope *et al.*[3], yielded a viscous, clear solution after centrifugation and filtration through sintered-glass micro-filters. To 50 μl. of extract in micro test-tubes 50 μl. of peptide solution (1·25–5·0 μmoles in 0·003 *N* sodium hydroxide) was added. After mixing by 'buzzing' on the shaft of a high-speed micro-motor, the tubes were incubated at 34° C. for 2 hr. together with separate tubes containing the same concentrations of the different peptides with only glycerol-phosphate buffer. After the incubation period, all tubes were chilled, 50 μl. of neutralized (phenolphthalein) 37 per cent formaldehyde and 4 μl. of 0·1 per cent phenolphthalein in 50 per cent ethanol were added to each tube. The formol titration was carried out against 0·1 *N* sodium hydroxide in a titration apparatus similar to that described by Linderstrøm-Lang and Holter[4]. The peptide and tissue blanks were subtracted from the enzyme-test values. The results are expressed in Fig. 1 and Table 1. The hydrolysis curve for DL-alanyl-glycine under the same conditions is presented for comparison in Fig. 1. Our observations indicate that the presence of a lipophilic aliphatic or aromatic side-chain is essential for dipeptidase activity in this category of dipeptides. Thus diglycine shows minimal splitting while all other glycyl-L-amino-acid dipeptides are maximally split. In keeping with the systematic difference, glycyl-γ-amino-butyric acid showed no splitting (Fig. 1), while the enzymatic hydrolysis of the glycyl-DL-α-amino-butyric acid was of the same order as the other dipeptides with a C-terminal DL-aliphatic or aromatic α-amino-acid residue. Similarly, glycyl-L-proline showed minimal hydrolysis under these conditions.

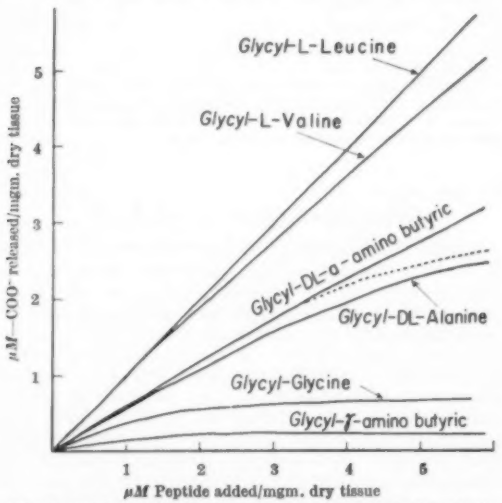

Fig. 1. Differences in peptidase activity of mouse brain dependent on presence of aliphatic side-chain of *N*-glycyl-dipeptides. The hydrolysis curve of DL-alanyl glycine at different peptide concentrations (dotted line merging with curve for glycyl-DL-α-aminobutyric acid) is included for comparison

Table 1

μM Peptide added/mgm. dry weight of brain	μM—COO⁻ released/mgm. dry weight of brain		
	1·5	2·5	5·0
Glycyl-glycine	0·50	0·55	0·72
Glycyl-L-alanine	1·45	2·40	4·47
Glycyl-L-valine	1·48	2·32	4·50
Glycyl-L-isoleucine	1·30	2·19	4·32
Glycyl-L-leucine	1·50	2·50	4·95
Glycyl-L-tyrosine	1·50	2·30	4·32*
Glycyl-L-phenylalanine	1·42	2·40	4·82
Glycyl-DL-alanine	0·82	1·34	2·30
Glycyl-DL-α-aminobutyric	0·90	1·45	2·78
Glycyl-DL-valine	1·04	1·60	2·73
Glycyl-DL-phenylalanine	0·80	1·26	2·20
Glycyl-L-proline†	0·40	0·40	0·40

* At this concentration the enzymatically released L-tyrosine precipitates out but redissolves during the formol titration.
† L-Proline in free form gives only 50 per cent of expected molar value in formol titration.

To our knowledge the existence of such structural requirements in the substrate was unsuspected for brain dipeptidase activity.

The same quantitative differences were observed when freeze-dried sections of mouse brain were extracted with 30 per cent glycerol in phosphate buffer, as well as when the peptides were incubated in the presence of fresh brain tissue slices in the glycerol-phosphate buffer solution without centrifuging off the slices to obtain a clear extract. In each instance the hydrolytic cleavage of each dipeptide, or lack of splitting, into component amino-acids was confirmed by paper chromatography. Incubation at 37° C. gave results identical with results of experiments carried out at 34° C.

Studies on a wide spectrum of related di- and tripeptides will be published in detail elsewhere.

This research was supported by a grant (*B*–712 *C5*) from the National Institute of Neurological Diseases and Blindness, U.S. Public Health Service.

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Methane Exhalation in Sheep

In view of the statements by Brody[1], Ritzman and Benedict[2], and Blaxter[3] to the effect that the ruminant exhales methane, it was deemed necessary to investigate the amount of methane which might be accumulated in the oxygen spirometer during indirect calorimetry experiments with sheep on full rations.

Appropriate arrangements were therefore made for gas analyses to be carried out by the Dominion Physical Laboratory at Wellington. On March 3, 1957, seven animals maintained on hay, crushed oats, and peas were chosen at random and each in turn was attached to the oxygen spirometer in the normal manner until it had exhausted one half the reservoir

capacity—a period of about 10 min. The gas remaining in the spirometer was then collected and analysed. The results of the analysis of these samples are presented in Table 1.

Table 1. Results of Analyses of Gas Samples drawn after the Sheep had Exhausted Half the Reservoir Capacity of a Closed Circuit Oxygen Spirometer*

Sheep No.	7	8	10	20	2	5	*X*
Methane	0·30%	0·05%	0·15%	0·20%	0·15%	0·15%	0·05%
Hydrogen	(0·02% or less)	(		not found			)

* Hydrogen was included by the Dominion Physical Laboratory and is presented here for general interest.

There was no possible way in which the methane could have entered the spirometer other than from the lungs of the sheep. However, in view of the fact that in tracheotomized sheep some of the eructated gases flow back down the trachea—this was believed to be an original observation—the presence of traces of methane in the pulmonary system may have been due to residues from previous eructations. As the spirometer graphs used cannot be ruled to a greater accuracy than 0·05 l., a possible volume error of at the most 3 ml. of methane per 5 min. is considered to be low enough to be ignored in these experiments.

This work was supported by the Research Committee of the University of New Zealand. Particular thanks are due to the Director of the Dominion Physical Laboratory, Wellington, for offering the necessary laboratory staff and facilities.

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Erythropoietine Production in the Dog

An erythropoiesis-stimulating factor has been reported present in the plasma of numerous animals including the dog[1]. The dog, although readily available and a convenient source of relatively large volumes of plasma, has been utilized sparingly[2]. The present study was made in order that the hæmopoietic factor might be determined in the dog following exposure of the animal to various experimental procedures which are known to affect production of the factor in other species.

Five normal adult mongrel female dogs were placed in each of the following donor groups and subjected to the procedure indicated: group 1, untreated, healthy animals used as controls; group 2, hæmorrhage, 20 ml./kgm./day for 4 days; group 3, phenylhydrazine hydrochloride, 2·5 per cent, adjusted to *p*H 7·0, administered subcutaneously, 7·5 mgm./kgm./day, until the hæmoglobin concentration declined to 3·5–5·0 gm./100 ml.; group 4, the dog maintained in a closed chamber, in which the gases were mixed by a fan, with carbon dioxide being absorbed by soda lime. A mixture of 9 per cent oxygen–91 per cent nitrogen was admitted at a rate of 6 litres/min. for 24 hr.

At the end of the experimental period, each animal was bled, and 'protein-free' plasma prepared by the methods of Borsook[3], and Gordon[4]. This plasma preparation, pooled from each group, was injected intraperitoneally, in doses of 1·0 ml./100 gm./day, for 7–9 days into 200-gm. female Sprague–Dawley rats the hæmatological values of which had been determined. Terminally blood was removed by cardiac puncture from the 20 rats in each recipient group for determination of hæmoglobin, hæmatocrit, erythrocyte and reticulocyte values. The results in Table 1 indicate that the plasma from all donor groups, excepting that of the control animals, produced erythropoietic stimulation in the recipients. Additionally, the plasma of the phenylhydrazine-treated group stimulated erythrocyte production. In no case was reticulocyte percentage increased. The dog, like other animals, responds to appropriate stimuli by increased production of the erythropoietic-stimulating factor.

Table 1. Effect of 'Protein-Free' Plasma of Dog on Red Cell Values in Rats

(Mean ± *S.E.*)	Hæmoglobin (gm./100 ml.)	Hæmatocrit (per cent)	Red blood count (mill./c.mm.)	Retics. (per cent)
Donors: (1) Control, normal dogs				
Rats: Before	14·9±0·15	45·0±0·30	8·4±0·26	1·1±0·17
After	14·6±0·18	44·4±0·18	8·7±0·13	1·3±0·21
(2) Hæmorrhaged dogs				
Rats: Before	13·8±0·19	40·8±0·88	7·8±0·23	2·2±0·21
After	14·9±0·16*	45·1±0·46*	7·9±0·14	1·7±0·19
(3) Phenylhydrazine-treated dogs				
Rats: Before	14·5±0·19	44·0±0·63	8·1±0·23	1·5±0·27
After	15·7±0·15*	47·3±0·35*	9·5±0·23*	1·4±0·18
(4) Hypoxic dogs				
Rats: Before	13·5±0·17	41·5±0·51	8·0±0·19	2·3±0·21
After	15·0±0·17*	45·5±0·56*	8·3±0·15	2·9±0·26

* Indicates probability value, $P < 0·01$ for means 'after' as compared to those 'before'.

This investigation was supported in part by a grant from the National Institutes of Health, U.S. Public Health Service.

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Ackee Toxin: a Riboflavin Antimetabolite?

There has occurred in Jamaica an illness known as 'vomiting sickness', characterized by vomiting, coma and death, which has been attributed to a toxin present in the ackee (*Blighia sapida*)[1–3]. In the course of routine assay for the protein values of human diets, a Jamaican meal containing this fruit was prepared, fed to rats, and the animals lost 26 per cent of their initial body-weight in 10 days. On a dry-weight basis, the meal contained 39 per cent green banana, 26 per cent salted cod-fish, 9 per cent coco-nut oil, 6 per cent salted pork fat, and 20 per cent ackee. Despite the high total protein content (17 per cent) of this mixture, it has a net dietary-protein value[4] of zero.

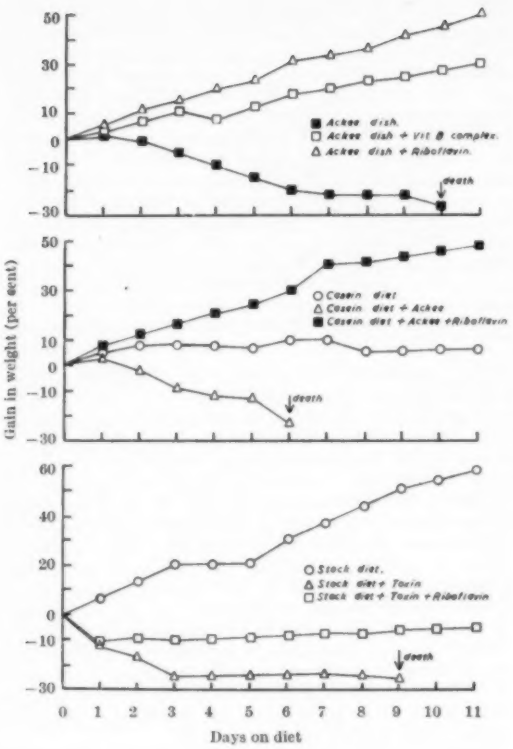

Fig. 1

By feeding each of the components of the meal separately in diets adequate in all nutrients, all were found to be innocuous, and the losses in weight on the complete meal were only prevented by supplementation with B vitamins, or more particularly with riboflavin (see Fig. 1). However, it is evident that simple riboflavin deficiency would not result in such an immediate and severe loss of weight[5] and, furthermore, analysis showed the diet to contain 0·28 mgm. riboflavin per 100 gm., which would supply the daily requirement for the rat[6]. This suggests that the meal contained an antimetabolite of riboflavin.

In another experiment the ackee was added to a synthetic, low-vitamin diet and was shown to produce a severe depression in growth-rate compared with a control. The addition of B-vitamins overcame both the adverse effect of the ackee and the low vitamin content of the diet: this is in agreement with the finding described above, where the toxic effects of the fruit could not be demonstrated with a diet containing 1 mgm. riboflavin per 100 gm.

Feng and Kean[7] have reported a protective action of protein to rats injected with a toxic material extracted from the ackee, but this work does not support their finding; in fact, 17 per cent casein in the absence of riboflavin was unable to prevent severe loss of weight and death when ackee was present in the diet. In addition, animals fed a low-protein diet adequate in B-vitamins lost 20 per cent of their weight in 10 days, whether or not ackee was added to the diet. These authors may have inadvertently added riboflavin concomitantly with protein in raising the level of nitrogen in the diet.

Finally we were able to obtain a sample of hypoglycin *A* extracted from ackees and have demonstrated that, when given subcutaneously (60 μgm./gm. body-weight), its toxic effects may be alleviated by simultaneous injection (120 μgm./gm. body-weight) with riboflavin. De Renzo *et al.*[8] have suggested from their studies with rat liver mitochondria that hypoglycin *A* is metabolized to the true toxic agent, and it is of interest that our sample did not interfere with the microbiological assay of riboflavin.

This work is supported by two clinical observations. Hill[2] has reported that many medical officers in charge of districts and hospitals throughout Jamaica noticed severe signs of riboflavin deficiency in the majority of cases of illness in which the ackee was implicated, and confirmed this view during the epidemic of 1951. Secondly, the incidence of the condition has been less frequent in recent years, during which there has been a rising consumption of wheat flour[9], a relatively good source of riboflavin.

This work formed part of an M.Sc. thesis by one of us[10] and is being continued with the view of establishing the mode of action of the antimetabolite. We are indebted to Prof. C. H. Hassall and Dr. S. J. Patrick for samples of hypoglycin *A*.

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RADIOBIOLOGY

Cæsium-137 in Spray-dried Danish Milk

The cæsium-137 content in Danish spray-dried milk has been measured in some fifty samples ranging in production time from 1949 to December 1959.

The measurements are carried out by γ-scintillation spectrometry using a Harshaw sodium iodide (thallium) crystal, 1½ in. diameter by 1½ in. thick, mounted in an electrolytic pure copper housing incorporating a quartz window. The 99-channel analyser used is of the analogue-to-digital conversion type built at this Laboratory and described elsewhere[1]. The resolution at 662 keV. is 8·3 per cent measured with a point source and approximately 10 per cent when a 800-gm. sample is counted. Fig. 1 shows sample container and detector in position inside the lead shield. The dried milk is measured without ashing or chemical treatment.

In Fig. 2 the upper curve shows a typical spectrum after subtraction of background. The potassium-40 peak at 1,460 keV. and cæsium-137 peak at 662 keV. are well resolved. No other peaks are significant. Sugar was used as background medium. The lower curve in Fig. 2 is that obtained with the cæsium-137 standard, while the points with their standard deviations are obtained from the upper curve by

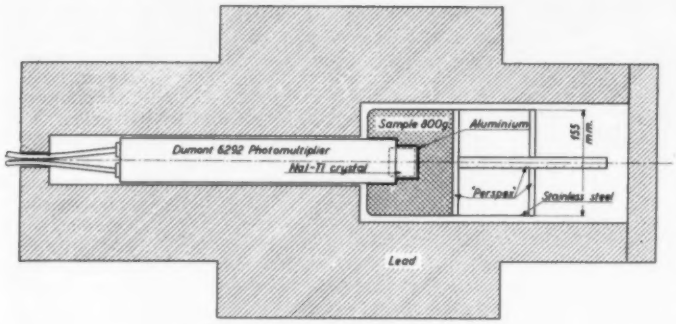

Fig. 1. Sample container and detector

subtracting the potassium-40 contribution. The points are seen to follow the cæsium-137 standard fairly well. 1 count/min. under the potassium-40 photopeak corresponds to 2·1 gm. of potassium in an 800-gm. sample, and 1 count/min. in the cæsium-137 photopeak corresponds to 98·1 μμc. of cæsium-137 in an 800-gm. sample.

The results are shown graphically in Fig. 3.

The peak value up to 1959 is about 20 μμc. cæsium-137/gm. potassium, which is rather low compared to figures given by E. C. Anderson *et al.*[2], who have measured two samples from Denmark and found 52 and 74 μμc. cæsium-137/gm. potassium respectively. Their samples were manufactured in June and September 1958. Our figures seem to correspond fairly well with those given by K. Løw and K. Edwarson[3] for Swedish milk but they are lower than the values quoted by Mayneord *et al.*[4] and by Booker[5].

Maybe the relatively low content of cæsium-137 in Danish milk is due partly to the large amount of fertilizer used in Denmark. On the average, 3·2 gm. potassium is used per m.² per annum. The average rainfall is 750 mm. in Aabenraa and 600 mm. in Hjørring per annum. No strontium determinations have so far been carried out on our samples.

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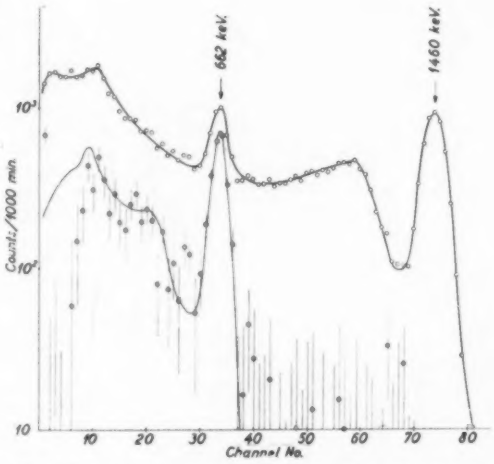

Fig. 2. Upper curve: spectrum of specimen after subtraction of background. Lower curve: spectrum of cæsium-137 standard

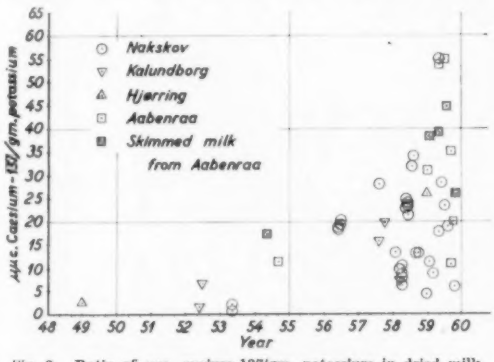

Fig. 3. Ratio of μμc. cæsium-137/gm. potassium in dried milk as a function of date of production

Mechanism of the Radiation Effect on the Synthesis of Deoxyribonucleic Acid

Work on the mechanism of the radiation effect upon the synthesis of deoxyribonucleic acid in human bone marrow cells *in vitro* indicated a biphasic X-ray dose-response curve[1]. To test the applicability of these findings to other mammalian cell systems, similar work has been carried out with mouse Ehrlich ascites tumour cells; this system also has the advantage of being a more homogeneous cell population than bone marrow.

Seven- to ten-day-old tumour was used; the ascitic fluid was immediately aspirated by syringe, suspended in heparinized supplemented Hanks's solution and centrifuged at 1,200 rev./min. for 10 min. The supernatant was discarded and the cells resuspended in a medium consisting of 50 per cent supplemented Hanks's solution and 50 per cent human serum to a concentration of 10^7 cells/ml. Aliquots of 1 ml. were then placed in 16 screw-cap culture vessels, of which four served as controls and four for each X-ray dose-level. X-rays were produced by a 300 kVp. resonant transformer, 1·9 mm. copper half-value layer at a dose rate of 475 rads/min. Irradiation was so arranged that all the doses were completed simultaneously. ^{14}C–thymidine, 0·5 μc./ml. culture, was added immediately after irradiation and the vessels incubated for 2 hr. at 37° C. Synthesis of deoxyribonucleic acid was measured by counting the total radioactivity of washed cells on planchettes prepared by the method of Lajtha *et al.*[2]; the number of cells per planchette was checked by ultra-violet absorption spectrometry. The results are shown in Fig. 1; each point represents the mean of eight experiments.

As in human bone marrow, the curve is at least biphasic, though less clear-cut. A steep initial depression (S_1) is again followed by a shallower slope at higher doses (S_2). The mechanism by which

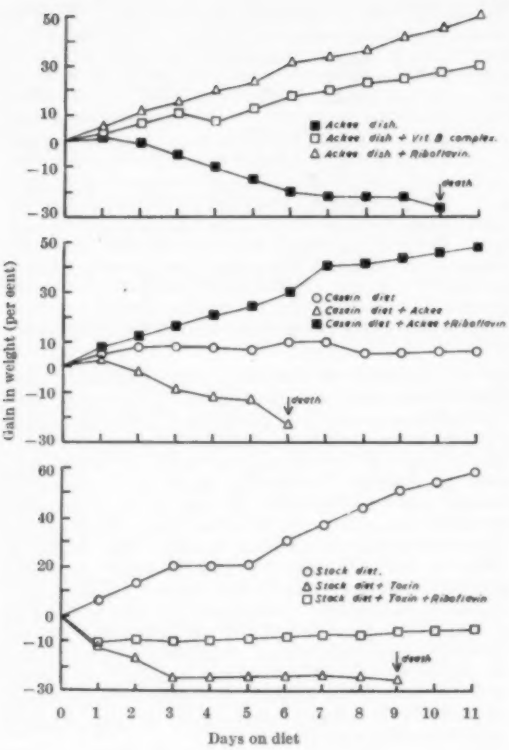

Fig. 1

By feeding each of the components of the meal separately in diets adequate in all nutrients, all were found to be innocuous, and the losses in weight on the complete meal were only prevented by supplementation with B vitamins, or more particularly with riboflavin (see Fig. 1). However, it is evident that simple riboflavin deficiency would not result in such an immediate and severe loss of weight[5] and, furthermore, analysis showed the diet to contain 0·28 mgm. riboflavin per 100 gm., which would supply the daily requirement for the rat[6]. This suggests that the meal contained an antimetabolite of riboflavin.

In another experiment the ackee was added to a synthetic, low-vitamin diet and was shown to produce a severe depression in growth-rate compared with a control. The addition of B-vitamins overcame both the adverse effect of the ackee and the low vitamin content of the diet: this is in agreement with the finding described above, where the toxic effects of the fruit could not be demonstrated with a diet containing 1 mgm. riboflavin per 100 gm.

Feng and Kean[7] have reported a protective action of protein to rats injected with a toxic material extracted from the ackee, but this work does not support their finding; in fact, 17 per cent casein in the absence of riboflavin was unable to prevent severe loss of weight and death when ackee was present in the diet. In addition, animals fed a low-protein diet adequate in B-vitamins lost 20 per cent of their weight in 10 days, whether or not ackee was added to the diet. These authors may have inadvertently added riboflavin concomitantly with protein in raising the level of nitrogen in the diet.

Finally we were able to obtain a sample of hypoglycin *A* extracted from ackees and have demonstrated that, when given subcutaneously (60 μgm./gm. body-weight), its toxic effects may be alleviated by simultaneous injection (120 μgm./gm. body-weight) with riboflavin. De Renzo *et al.*[8] have suggested from their studies with rat liver mitochondria that hypoglycin *A* is metabolized to the true toxic agent, and it is of interest that our sample did not interfere with the microbiological assay of riboflavin.

This work is supported by two clinical observations. Hill[3] has reported that many medical officers in charge of districts and hospitals throughout Jamaica noticed severe signs of riboflavin deficiency in the majority of cases of illness in which the ackee was implicated, and confirmed this view during the epidemic of 1951. Secondly, the incidence of the condition has been less frequent in recent years, during which there has been a rising consumption of wheat flour[9], a relatively good source of riboflavin.

This work formed part of an M.Sc. thesis by one of us[10] and is being continued with the view of establishing the mode of action of the antimetabolite. We are indebted to Prof. C. H. Hassall and Dr. S. J. Patrick for samples of hypoglycin *A*.

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RADIOBIOLOGY

Cæsium-137 in Spray-dried Danish Milk

The cæsium-137 content in Danish spray-dried milk has been measured in some fifty samples ranging in production time from 1949 to December 1959.

The measurements are carried out by γ-scintillation spectrometry using a Harshaw sodium iodide (thallium) crystal, 1½ in. diameter by 1½ in. thick, mounted in an electrolytic pure copper housing incorporating a quartz window. The 99-channel analyser used is of the analogue-to-digital conversion type built at this Laboratory and described elsewhere[1]. The resolution at 662 keV. is 8·3 per cent measured with a point source and approximately 10 per cent when a 800-gm. sample is counted. Fig. 1 shows sample container and detector in position inside the lead shield. The dried milk is measured without ashing or chemical treatment.

In Fig. 2 the upper curve shows a typical spectrum after subtraction of background. The potassium-40 peak at 1,460 keV. and cæsium-137 peak at 662 keV. are well resolved. No other peaks are significant. Sugar was used as background medium. The lower curve in Fig. 2 is that obtained with the cæsium-137 standard, while the points with their standard deviations are obtained from the upper curve by

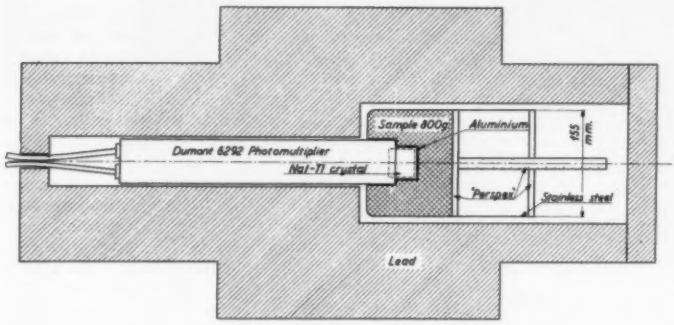

Fig. 1. Sample container and detector

subtracting the potassium-40 contribution. The points are seen to follow the cæsium-137 standard fairly well. 1 count/min. under the potassium-40 photopeak corresponds to 2·1 gm. of potassium in an 800-gm. sample, and 1 count/min. in the cæsium-137 photopeak corresponds to 98·1 μμc. of cæsium-137 in an 800-gm. sample.

The results are shown graphically in Fig. 3.

The peak value up to 1959 is about 20 μμc. cæsium-137/gm. potassium, which is rather low compared to figures given by E. C. Anderson *et al.*[2], who have measured two samples from Denmark and found 52 and 74 μμc. cæsium-137/gm. potassium respectively. Their samples were manufactured in June and September 1958. Our figures seem to correspond fairly well with those given by K. Løw and K. Edwarson[3] for Swedish milk but they are lower than the values quoted by Mayneord *et al.*[4] and by Booker[5].

Maybe the relatively low content of cæsium-137 in Danish milk is due partly to the large amount of fertilizer used in Denmark. On the average, 3·2 gm. potassium is used per m.² per annum. The average rainfall is 750 mm. in Aabenraa and 600 mm. in Hjørring per annum. No strontium determinations have so far been carried out on our samples.

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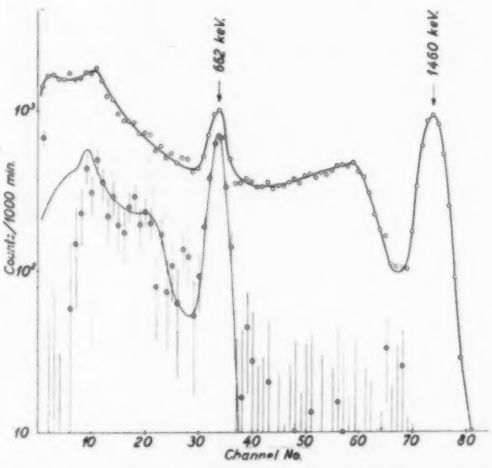

Fig. 2. Upper curve: spectrum of specimen after subtraction of background. Lower curve: spectrum of cæsium-137 standard

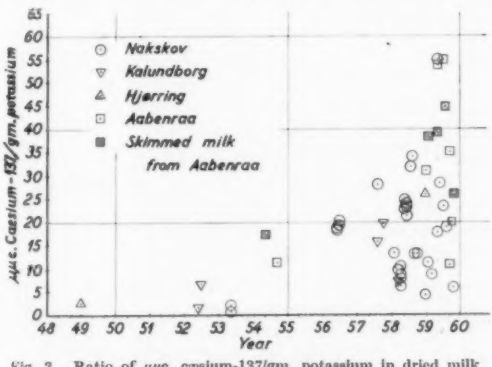

Fig. 3. Ratio of μμc. cæsium-137/gm. potassium in dried milk as a function of date of production

Mechanism of the Radiation Effect on the Synthesis of Deoxyribonucleic Acid

Work on the mechanism of the radiation effect upon the synthesis of deoxyribonucleic acid in human bone marrow cells *in vitro* indicated a biphasic X-ray dose-response curve[1]. To test the applicability of these findings to other mammalian cell systems, similar work has been carried out with mouse Ehrlich ascites tumour cells; this system also has the advantage of being a more homogeneous cell population than bone marrow.

Seven- to ten-day-old tumour was used; the ascitic fluid was immediately aspirated by syringe, suspended in heparinized supplemented Hanks's solution and centrifuged at 1,200 rev./min. for 10 min. The supernatant was discarded and the cells resuspended in a medium consisting of 50 per cent supplemented Hanks's solution and 50 per cent human serum to a concentration of 10^7 cells/ml. Aliquots of 1 ml. were then placed in 16 screw-cap culture vessels, of which four served as controls and four for each X-ray dose-level. X-rays were produced by a 300 kVp. resonant transformer, 1·9 mm. copper half-value layer at a dose rate of 475 rads/min. Irradiation was so arranged that all the doses were completed simultaneously. ^{14}C–thymidine, 0·5 μc./ml. culture, was added immediately after irradiation and the vessels incubated for 2 hr. at 37° C. Synthesis of deoxyribonucleic acid was measured by counting the total radioactivity of washed cells on planchettes prepared by the method of Lajtha *et al.*[2]; the number of cells per planchette was checked by ultra-violet absorption spectrometry. The results are shown in Fig. 1; each point represents the mean of eight experiments.

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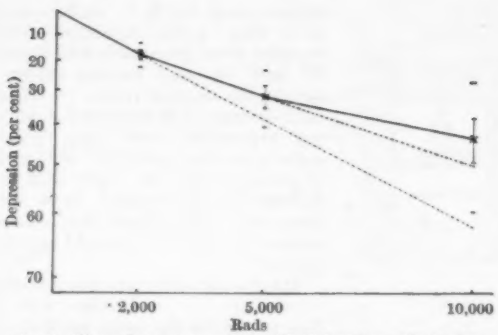

Fig. 1. X-ray dose-response curve, Ehrlich ascites cells *in vitro*. Each point represents the mean of eight experiments. Vertical bars indicate standard error of mean; standard deviation of individual experiments indicated by the short horizontal bars. Interrupted line from 2,000 to 10,000 rads indicates extrapolation of S_1 slope, that between 5,000 and 10,000 rads indicates dubious break in S_2 slope

irradiation inhibits synthesis of deoxyribonucleic acid is still unexplained; possibly S_1 represents some enzymatic inhibition[3] and S_2 the inhibition of the template replication of the deoxyribonucleic acid molecule. Variation in the radiosensitivity of the cells sufficient to explain the curve is unlikely, as autoradiographic work with ^{3}H-thymidine in similar experiments indicates a general shift of the grain counts to lower levels.

The effect of oxygen on the inhibition of synthesis of deoxyribonucleic acid by X-irradiation has been investigated for the initial (S_1) slope of the dose-response curve. Ehrlich ascites cells were suspended as before and placed in flat glass Petri dishes within a pressure vessel. The cell suspensions were equilibrated for 5 min. at room temperature with either 100 per cent oxygen or oxygen-free nitrogen and then rotated for 15 min. on an inclined turntable to ensure full equilibration of all cells with the gas phase. Irradiation was carried out while the cell suspensions were thus being rotated (300 kVp., 0·5 mm. copper + 1 mm. aluminium added filtration, dose-rate 280 r./min.). The cells were then incubated with ^{14}C–thymidine and planchettes were prepared as before. The results are shown in Fig. 2; at doses of both 800 and 2,000 rads (measured by ferrous sulphate), there was a markedly greater inhibition of the incorporation of ^{14}C–thymidine in the oxygenated suspensions. The ratio oxygen/nitrogen averaged 2·9.

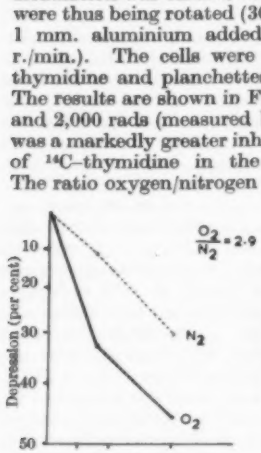

Fig. 2

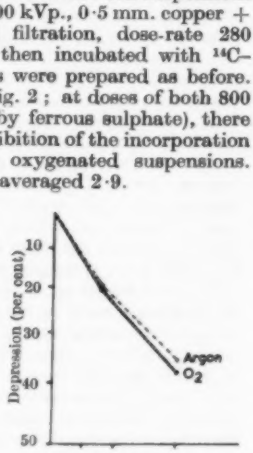

Fig. 3

Fig. 2. 'Oxygen effect', radiosensitivity of S_1 component. Each point at a given X-ray dose-level represents an experiment with quadruplicate controls

Fig. 3. Inability of 37 atm. argon + 1 atm. air to simulate anoxic conditions in modifying radiosensitivity of S_1 component. Each point at a given X-ray dose-level represents an experiment with quadruplicate controls

Ebert, Hornsey and Howard[4] noted that inert gases under pressure in the presence of normal atmospheric concentration of oxygen could simulate anoxic conditions in modifying radiosensitivity of several cell systems, including the production of abnormal anaphases in Ehrlich ascites cells. These cells show an 'oxygen effect' of a factor of 2·7–3·1 as demonstrated by Deschner and Gray[5]. To test an inert gas in this system, argon at 37 atm. + 1 atm. air was introduced over normally aerated cell suspensions in a pressure vessel and the vessel then rotated on the inclined turntable for 15 min. The control (oxygen) suspension was equilibrated for 5 min. with 100 per cent oxygen bubbled through water, then the vessel was rotated as before. The suspensions were irradiated and incubated as above. The results are shown in Fig. 3; the radiosensitivity in air + argon did not differ from that in oxygen at either dose-level.

The difference in the absolute values of the depression of deoxyribonucleic acid synthesis in oxygen between these experiments and those of Fig. 2 may be ascribed partly to the fact that the earlier experiments were performed with dry gas (permitting additional damage to the cells by dehydration and consequent hypertonicity of the medium), whereas in the latter water-saturated gas was used. It is significant, however, that in each experiment where both oxygenated and nitrogenated suspensions of the same tumour received identical treatment with the exception of the gas used, there was a marked difference between radiosensitivity in the two gases. By contrast, in the experiments in which oxygen and air + argon were used, there was no difference in radiosensitivity at either dose-level. The degree of depression shown in the dose-response curve in Fig. 1 suggests that the cell system was 'anoxic', as would be expected from the findings of Deschner and Gray[5], and that due to the closed system (rather than open Petri dishes) the cells were not additionally damaged by dehydration of the medium.

These experiments re-affirm the multiphasic (S_1, S_2) X-ray dose-response curve for the synthesis of deoxyribonucleic acid. They also indicate the dependence on oxygen of the radiosensitivity of the S_1 process; experiments to determine whether the S_2 process is similarly dependent on oxygen are in progress. The failure of inert gases to modify this response suggests that it is not due to effects at an intranuclear lipid interface where the inert gases have been postulated to act[4].

These experiments were supported by a grant from the Medical Research Council; one of us (R. J. B.) is British-American Exchange Fellow of the American Cancer Society.

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BIOLOGY

Golgi Bodies and Golgi Zones in Molluscan Oocytes

In the cytoplasm of the oocytes of *Aplysia depilans* L. (Mollusca, Opistobranchia), during the first phases of growth, a large quantity of Golgi bodies or dictyosomes can be found. Such bodies can be observed with the optical microscope with the silver impregnation methods and they are generally arranged along a bent line (Fig. 1). The same bodies can also be observed with the electron microscope (Fig. 2), and in this instance they show a closed system of double parallel membranes (Fig. 5) and not an open system, as generally observed by previous authors. Inside these bodies[1] there are vacuoles with a clear content and vesicles with a dark content, which correspond to similar structures of the open system. In the oocytes of *Aplysia* vitellogenesis takes place following a radical transformation of Golgi bodies into yolk globules, as already observed by Parat[2] in *Aplysia punctata*.

Electron microscope observations showed that the following growth stages of such globules take place by means of peculiar particles which are characterized by a central clear zone and by a peripheral zone, that is, composed of dark granulations with a diameter of about 300 Å. The particles arrange themselves around each globule in the shape of a half-moon (Fig. 4), which is evident also in silver method preparations as observed with the optical microscope (Fig. 3). When the globules have reached their maximum in growth, these particles are no longer present, but a semi-lunar globule can still be observed (Fig. 6). It differs, however, from the previously cited half-moon as it cannot be impregnated by silver methods and it shows different ultrastructural peculiarities (Fig. 6). The further phases of vitellogenesis in *Aplysia* have been reported in earlier communications[3,4].

In the oocytes of *Patella coerulea* L. (Mollusca, Prosobranchia) dictyosomes like those of *Aplysia* cannot be found. The formation of yolk globules takes place from the beginning in direct connexion with the ergastoplasm[4,5]. This is formed by filaments of a thickness of about 200 Å., which carry dark granulations measuring about 300 Å. in diameter. The presence of a semi-lunar formation around growing yolk globules can be observed both with the silver impregnation methods with the optical microscope (Fig. 7) and with the electron microscope. This formation disappears when the globules have attained their full development. Such formation clearly corresponds to that formed by the dark granulations of 300 Å. in diameter, which are attached to the filaments.

The above results demonstrate, with reference to the Golgi apparatus, that it is possible to distinguish two types of elements which are both evidenced through the silver impregnation. The first elements have been found only in *Aplysia*, and they correspond, from the ultrastructural point of view, to typical Golgi bodies; the second elements, which have been found both in *Aplysia* and in *Patella*, show totally different characters. It is therefore highly probable that the semi-lunar zones, which surround the developing yolk globules, are the expression of peculiar physico-chemical conditions, that are connected with intense synthetic processes and favour silver precipitations at their level. When such synthetic processes come to an end, silver is no longer precipitated. This allows the distinction of two different aspects of the Golgi apparatus: one is represented by typical Golgi bodies or dictyosomes according to Grassé, Carasso and Favard[6], and another is represented by Golgi zones, which have a different constitution and are connected with intense synthetic processes.

Contrasting views regarding the different elements of the Golgi apparatus can thus be reconciled. Such solution was already foreshadowed by conclusions reached by a few authors, such as Levi[7] and Dalton[8]. Grassé's[9] contention that the Golgi zone has no reality and that the Golgi apparatus is a definite organelle present in any cell appears thus to be highly restrictive from this point of view.

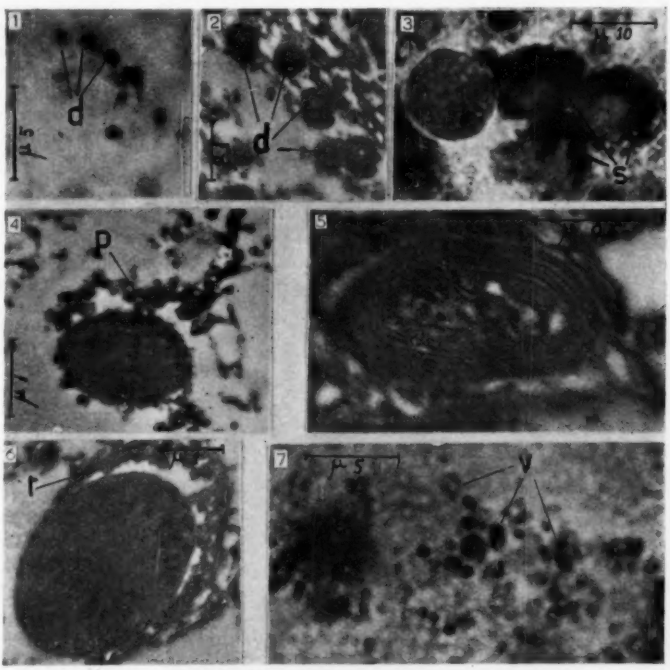

Fig. 1. Dictyosomes (*d*) of *Aplysia depilans* oocyte at the optical microscope; Da Fano silver impregnation. Fig. 2. The same dictyosomes (*d*) at the electron microscope. Fig. 3. Yolk globules of *Aplysia* oocyte at the optical microscope. Three of them are partly surrounded by a silver-impregnated semi-lunar zone (*s*). Fig. 4. Yolk globule of *Aplysia* oocyte at the electron microscope with particles (*p*) grouped into a semi-lunar arrangement. Fig. 5. Dictyosomes of *Aplysia* oocyte at the electron microscope. Fig. 6. Yolk globule of *Aplysia* oocyte with a very dense semi-lunar network (*r*) at the electron microscope. Fig. 7. Developing yolk globules in a *Patella coerulea* oocyte at the optical microscope. Some of them show a silver-impregnated half-moon (*V*). Observations at the electron microscope were carried out with a Siemens' Elmiskop Ia of the Centre for Electron Microscopy at the University of Padua

This work has been supported by Consiglio Nazionale delle Ricerche, Roma.

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Structure of the Outer Secondary Wall on Unbleached Spruce Sulphite Fibres

Numerous investigators, in particular Emerton[1], Wardrop[2] and one of us[3], have reported on the structure of the outer secondary wall, S_1, of coniferous fibres. In all cases, these investigations were carried out on fragments which had been freed from the fibres by some form of mechanical action. Although the evidence that these fragments originated from the S_1 wall is excellent, the S_1 wall has never been seen intact on the surface of a fibre.

We are at present carrying out investigations on some properties of unbleached spruce sulphite fibres. The fibres discussed here were mechanically treated in a 2-litre disintegrator for 80 min. at a consistency

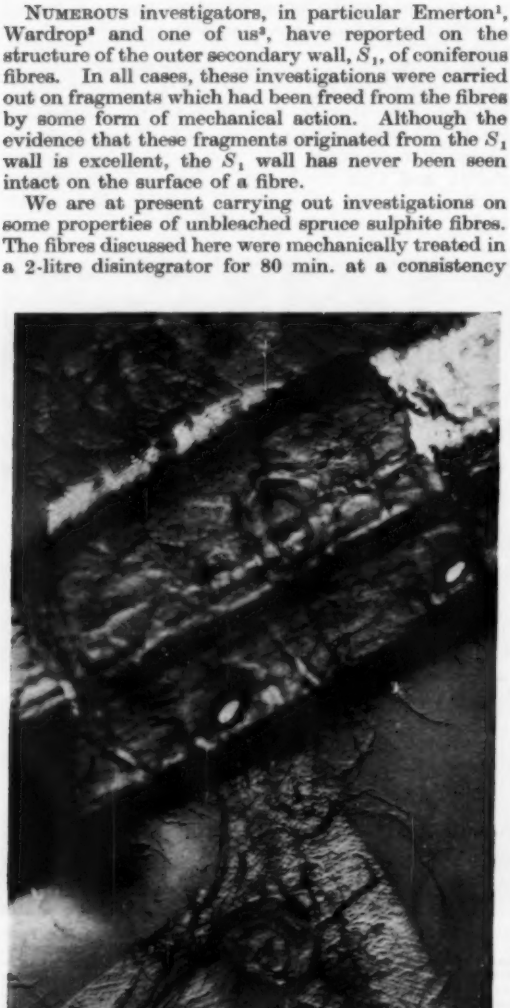

Fig. 1

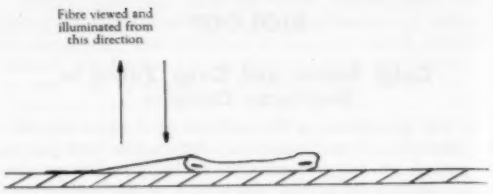

Fig. 2

of 1 per cent. After the disintegration, the fibres were screened thoroughly twice to remove the fine fragments released by stirring. Samples of the screened fibres were dried on to slides and without further treatment examined in a microscope under reflected light. (Zeiss microscope, model *W*, epi-illumination II*B*.) We found attached to many fibres typical S_1 fragments. In a few cases such as that shown in Fig. 1, the S_1 structure was clearly visible on the surfaces of the fibres. The alternate dark and bright lines between the fibre and the upper fragment are interference fringes (Newton's rings) formed in the wedge-shaped gap between the partially unravelled S_1 fragment and the slide[4] (see cross-sectional view of fibre in Fig. 2). The presence of the interference fringes is strong evidence that the unravelled S_1 fragment is attached to the top surface of the fibre.

The angle between each of the two sets of fibrils and the fibre axis (fibrillar angle) is about 50° (five measurements). The same value was obtained for the S_1 fragment in the upper portion of Fig. 1. Assuming that the longitudinal fibre axis of the other fragment is perpendicular to that of the fibre, its fibrillar angle is about 60°. These values agree well with those reported in refs. 1, 2 and 3.

We wish to thank the Directors of Wiggins Teape and Co., Ltd., for permission to publish this communication.

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Occurrence of *Falkenbergia rufolanosa* on the West Coast of Scotland

Periodic reports during the past twenty years[1-4] have noted the appearance of *Asparagopsis armata* and its associated form, *Falkenbergia rufolanosa*, in a number of localities in western Ireland and the south and south-west coasts of England. Although the southern records reported the two forms appearing almost simultaneously, recent evidence suggests that *Falkenbergia* is spreading round the British coasts more widely than *Asparagopsis*[5-7]; and this would seem to confirm the suggestion of Thomas[8] that the two differ in their ecological requirements.

Further evidence of the spread of *Falkenbergia* is seen in its appearance on the coast of Scotland. During

a survey of the inter-tidal zone of the coasts of the Hebridian island of Colonsay at the time of very low tides early in September 1959, filaments of a small polysiphonous alga showing three pericentral cells around each cell of the central filament were found on two shores: (*a*) intermingled with other small drift algae collected from the Strand between Colonsay and Oransay, and (*b*) as quite large, bright pink 'pom-poms' growing on *Cladophora rupestris* in Cable Bay, a small sandy bay at the south-east of Colonsay, where, again, it occurred much intermingled with other small epiphytic algae such as *Ceramium rubrum*, *Sphacelaria bipinnata*, *Lomentaria articulata* and *Achrochaetium* sp. This alga agrees with descriptions given for the vegetative state of *Falkenbergia rufolanosa*[2,3]. The filaments forming the well-marked 'pom-poms' were short and not much branched except towards the tips: they had the appearance of young, developing axes with markedly active apical cells. All the plants examined were sterile. On several filaments, propagules of *Sphacelaria bipinnata* were attached and were developing as epiphytes of the *Falkenbergia*.

It is hoped that other marine ecologists will keep a watch for further appearances of *Falkenbergia* in northern waters: it will be of considerable interest to see if it is followed in the Hebrides by *Asparagopsis*, or if the different distribution pattern of the two forms receives further confirmation.

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Perfect Stage of *Sclerotium rolfsii* Sacc.

The perfect stage of *Sclerotium rolfsii* Sacc. has been reported by several workers[1–6]; however, the conditions under which its development takes place have not been investigated thoroughly. An attempt was therefore made to find out the various nutritional and environmental factors which affect the development of the perfect stage.

The fungus was isolated from rotted potato tubers and grown on different media; also under different conditions of temperature, hydrogen-ion concentrations, and relative humidities. Different sources of carbon and nitrogen, as well as different concentrations of their best sources, were also tried, but no success was met with, until one day a plate of standard Brown's agar medium containing cultures of *S. rolfsii* and lying in the cupboard for 1¼ months was seen developing the fruiting body. An experiment was set up with seven agar media, namely, potato-dextrose, oatmeal, maize meal, host extract, Richard's, Czapek's and Brown's. Three plates of each were incubated at 25° C. and at room temperature in the cupboard.

The fruiting body developed only in the three plates containing Brown's agar medium incubated at room temperature during a period of 33–39 days. The mean maximum and minimum room temperatures for the period under observation were 19·9° C. and 14·4° C. respectively. This experiment was again repeated when the mean maximum and minimum room temperatures were 23·5° C. and 17·3° C. respectively, and similar results were obtained.

The descriptions and measurements of the fruiting body, basidium, and basidiospores resembled those reported earlier[3,4]. Basidiospores, when planted on potato dextrose agar, germinated and grew to form a mycelial mat and sclerotia. The mycelial, sclerotial, and growth characters of the basidiosporal cultures resembled those of the parent culture.

Brown's agar medium which developed the perfect stage is poor in nutrients as compared to the rest of the media. The special medium used with success by Mundkur[4] was also poor in nutrient. Curzi[2] also reported that sporulation in *S. rolfsii* took place earlier and was more abundant in media poor in nutrients as compared with media rich in nutrients. Reports of various workers[2,4,5] also indicate wide variation in the temperature requirement for the development of the perfect stage.

The development of perfect stage in *S. rolfsii* thus seems to depend both upon nutrient and temperature, and Brown's agar medium incubated at room temperature ranging between a mean maximum and minimum of 21·7° C. and 15·9° C. for 33–39 days is suitable for the development of the perfect stage.

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BACTERIOLOGY

Isolation of Mutants of *Bacillus subtilis* requiring D-Glutamic Acid

Although synthetic pathways of the L series of amino-acids have been studied extensively by the use of biochemical mutants of micro-organisms, there appears to be no published account of the synthesis of the D series of amino-acids using similar experimental techniques. Meanwhile, because D-glutamic acid is known to be an essential component of the cell wall and capsular fractions of a certain kind of bacteria[1,2], an attempt to obtain mutants requiring D-glutamic acid for growth is still valuable. With this idea, induction and isolation of mutants from a wild strain of *Bacillus subtilis K* requiring D-glutamic acid was attempted.

Minimal medium was prepared as prescribed by Gray and Tatum[3] (L-asparagine was eliminated), adding 0·1 per cent glucose for liquid medium and 0·5 per cent for solid medium. To allow the growth of mutants requiring D-glutamic acid, if any existed, a special medium (*DG*) consisting of 100 μgm./ml. of D-glutamic acid and the components in the minimal medium was prepared and used in place of the so-called complete medium. Spores of the wild strain were harvested from a 10-day culture on Burkholder's nutrient agar slant[4], and a suspension

Table 1. RESPONSE PATTERN OF THE FIVE MUTANTS ISOLATED

Amino-acids (100 μgm./ml.)	Mutant strains 1a	2a	3a	4a	3d
D-Glutamic acid	+	+	+	+	+
D-Aspartic acid	+	+	+	+	+
D-Alanine	+	+	−	−	+
L-Glutamic acid	−	−	+	+	−
L-Aspartic acid	−	−	+	+	−
L-Alanine	+	+	−	−	−
DL-Glutamic acid	+	+	+	+	+
DL-Aspartic acid	+	+	+	+	+
DL-Alanine	+	+	−	−	+
Minimal medium	−	−	−	−	−
Casein hydrolysate plus D-glutamic acid	+	+	+	+	−

containing 10^6–10^7 spores in 2 ml. of sterile saline was exposed to X-rays. The survival ratio at a dose of 144,000 röntgens was 20 per cent. After appropriate dilution, the cells were plated on *DG* medium. The replica plating method devised by Lederberg and Lederberg[5] was applied to the colonies that appeared on the plates, and such colonies which showed positive response to the *DG* medium, but not to minimal medium, were selected.

As a result, four out of about ten thousand colonies tested were proved to be mutants requiring D-glutamic acid. These mutants, *1a*, *2a*, *3d* and *4a*, are fairly stable though *3d* gave rise to a new mutant, *3a*, spontaneously. Growth response of these strains to D and L amino-acids was judged by shake culture method using about 10^6 cells/ml. as inocula. As seen in Table 1, all of them require D-glutamic acid for growth, but response to D-aspartic acid, D-alanine, L-glutamic acid, L-aspartic acid and L-alanine is different from strain to strain. For example, strain *3d* grows on a medium containing either D-glutamic acid, D-aspartic acid or D-alanine, while strains *3a* and *4a* grow on either a D-glutamic acid, D-aspartic acid, L-glutamic acid or L-aspartic acid supplemented medium. It is strange that strain *3d* cannot grow on a medium consisting of casein hydrolysate and D-glutamic acid; but this phenomenon may be due to a mutual effect between D-glutamic aoid and other amino-acids.

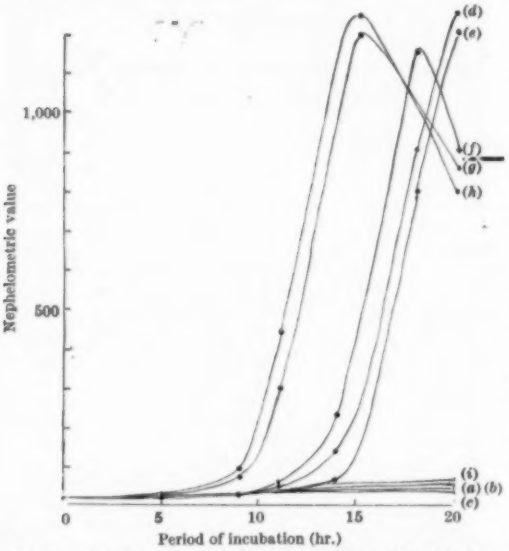

Fig. 1. Growth of strain *3d* in media supplemented with (*a*) L-glutamic acid, (*b*) L-aspartic acid, (*c*) L-alanine, (*d*) D-glutamic acid, (*e*) D-aspartic acid, (*f*) D-alanine, (*g*) DL-glutamic acid, or (*h*) DL-aspartic acid. (*i*) is minimal medium

Fig. 1 shows growth-curves of strain *3d* in media supplemented with 100 μgm./ml. of D, L or DL amino-acids, where cultivation was carried out in Monod tubes on a shaking machine at 37° C. Moreover, the minimal amount of D-glutamic acid sufficient to achieve full growth of strain *3d* was determined to be 5–10 μgm./ml. The number of viable cells decreased rapidly when strain *3d* was placed in a medium devoid of D-glutamic acid.

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T_4 and λ Phage Adsorption on Protoplast-like Bodies of *Escherichia coli*

DURING the past few years, methods have been developed for preparing spherical units of Gram-negative bacteria such as *E. coli*, which have often been described as 'large bodies' or 'protoplasts'. Unlike the protoplasts of Gram-positive bacteria, these spherical forms are also very sensitive to osmotic change. Whereas it can be shown by various methods that the cell wall is removed in the case of *B. megatherium*, this has not been proved conclusively for the spherical forms of *E. coli*. Since the cell wall of *E. coli*, unlike that of Gram-positive bacteria, contains a lipoprotein component as well as lipopolysaccharide[1] and at least four of five methods of preparation for spherical forms involve only polysaccharides, it is very probable that the spherical forms of *E. coli* are surrounded by cell-wall remains. If this is really the case, we may assume that these forms adsorb at least some of those phages, towards which the rod-shaped, normal cell is sensitive.

We have therefore investigated the adsorption of the T_4 and λ phages on spherical forms of *E. coli* strains.

This communication deals with the adsorption of phages T_2, T_5 and λ_{hc} on spherical forms of *E. coli*[2], strains *B*, 173–25 or *S*, which have been produced either with lysozyme[2a], penicillin[2b], phage enzyme[2c], glycine[2d] or by deprival of diaminopimelic acid[2e].

In general, the standard phage techniques, as described by Adams[3], have been used. Special techniques will be published in detail elsewhere. Normally, *E. coli* cells grown up to 2–5 × 10^8/ml. or dilutions 1 : 3–1 : 50 of overnight cultures were used. The conversion to spherical forms was made in media containing 12 per cent sucrose. Such conditions were chosen that at least 99 per cent of the cells were changed to the spherical form, that is, the survival rate after an osmotic shock (dilution 1 : 100 in phosphate-buffer 0·1 *M*, *p*H 7·0) was never higher than 1 per cent.

The adsorption of phages was studied in sucrose-broth (~100 gm. sucrose, 11 gm. peptone, 5·8 gm. sodium chloride/l.) over a period of 10 min. (phage T_2) or 15 min. (phages T_5 and λ_{hc}) at 37° C. Non-adsorbed phage was recovered after killing of the infected complexes with chloroform. The micro-

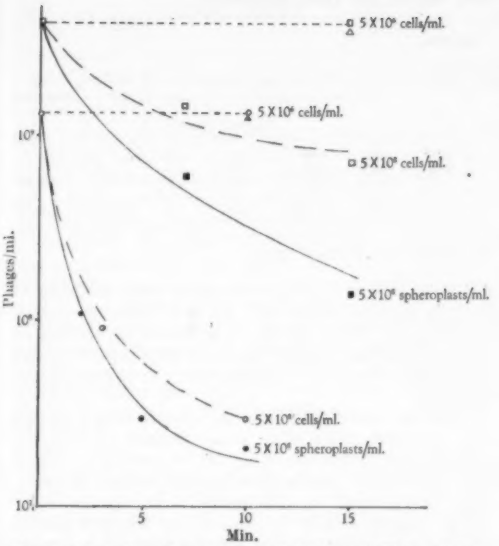

Fig. 1. Adsorption of phages T_2 and T_5 (● and ■) to spheroplasts obtained by treatment with 1,000 U./ml. penicillin in aerated culture at 37° C. during 75 min. (full symbols), to *E. coli* cells (empty symbols) and inactivation by cell-free supernatant of conversion medium (△)

scopically determined titre of the washed spherical forms was ~5 × 10^8/ml. in experiments with phages T_2, T_5 and ~10^9/ml. in experiments with phage λ_{Bc}.

Glycine treatment was also carried out in normal broth without addition of sucrose. In this case the conversion was only controlled by phase-contrast microscopy and the adsorption was measured in a sucrose-free medium.

As controls we used the conversion medium from which the cells had been removed by centrifugation, as well as normal *E. coli* cells of the same concentration as the spheroplasts and in a dilution 1 : 100. In this way we were able to take into account a possible adsorption on rod-shaped, non-converted bacteria and the inactivation of phage by soluble cell-wall material.

The comparison of adsorption by normal rod-shaped cells and spherical forms of equal titre should, under certain conditions, allow quantitative conclusions concerning the proportion of receptor substance still remaining.

A typical result is shown in Fig. 1. Phages T_2 and T_5 are adsorbed at the same rate on to *E. coli* cells as on to spherical forms (obtained by treatment with 1,000 U./ml. penicillin in aerated broth–sucrose medium during 75 min. at 37° C.).

The same rate of adsorption of the phages on both normal cells and spherical forms makes the assumption possible that the receptor substances for T_2 and T_5 phages remain quantitatively on the spheroplasts. But this assumption must be verified by further investigations in which a comparison between the highest possible number of adsorbed phages per spheroplast and per rod-shaped bacterium is made.

Similar results were obtained in parallel experiments with *E. coli* converted by phage-enzyme, lysozyme, glycine or by deprival of diaminopimelic acid and phages T_2 or T_5 and λ_{Bc}. These results provide strong evidence that *E. coli* cells, after conversion in liquid suspension, are not true protoplasts since these are defined as being the protoplasm completely depleted of the cell wall. Indeed, the receptors for the phage T_2 have been shown to be situated in the cell wall. It seems to be obvious, in general, that the receptors should be at the surface of the wall. In these circumstances the term 'spheroplast' is preferable to protoplast as suggested by S. Brenner and others[4].

We are now studying the adsorption of the other T_i phages. This may be another way to investigate the localization of phage receptors in the cell-wall components.

On the completion of this work we read the paper by G. Dénes and L. Polgár[5] on T_2 phage multiplication in 'protoplasts' obtained by penicillin treatment, and found it in close agreement with our results.

These investigations were started in the Laboratoire de Biophysique, Geneva. We wish to thank Prof. E. Kellenberger and his collaborators for their many suggestions and for the courtesy of providing us with phage and bacterial strains. We also thank Dr. McQuillen, Cambridge, from whom we received *E. coli* strain 17325 and a sample of diaminopimelic acid.

We are also indebted to Prof. A. Butenandt for his encouragement throughout the course of this work, and for making the studies in Geneva possible.

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The a–z–z_{35} Group of *Salmonella* Antigens

In the course of establishing the antigenic formula for a new *Salmonella* serotype, *S.* greenside, its specific-phase flagellar antigen (*z*) was found to differ from the usual type as seen in *S.* poona, but to be identical to that of *S.* bulawayo[1]. Taylor, in describing the antigen z_{35} of *S.* chittagong, mentioned its relationship to both *z* of *S.* poona and *a* of *S.* paratyphi A.[2]. Common factors between *a*, *z*, and the antigen z_{35} of *S.* cairina were also described by Kauffmann[3], although z_{35} in this case was found to be slightly different from that of *S.* chittagong.

In view of these findings, an attempt has been made to clarify the relationships between these antigens by means of a series of agglutinin-absorption tests.

Rabbit antisera preserved with 50 per cent glycerine were used throughout these experiments. Sera prepared from biphasic *Salmonellae* were given an initial absorption with packed bacterial cells containing antigens corresponding to the unwanted flagellar phase.

Absorption tests were done by emulsifying packed cells in 5-ml. volumes of each serum, incubating at 37° C. for 18 hr., and removing the supernatant fluid after centrifugation. This procedure was repeated

Table 1. Flagellar Agglutination Reactions Before and After Absorption

Agglutinable suspensions	Antisera											
	z (poona)	z (poona) absorbed with		z (bulawayo)	z (bulawayo) absorbed with		z_{35}	z_{35} absorbed with			a	a absorbed with z_{35}
		z (bulawayo)	z_5		z (poona)	z_{35}		a	z (poona)	a + z (poona)		
S. poona (*z*)	2,560	160	1,280	2,560	0	320	640	160	0	0	0	0
S. bulawayo (*z*)	640	0	160	2,560	80	640	320	160	0	0	0	0
S. chittagong (z_{35})	640	0	0	640	0	0	2,560	1,280	1,280	320	40	0
S. paratyphi A. (*a*)	0	0	0	0	0	0	1,280	0	640	0	2,560	2,560

Note: 0 equals negative at 1/10 dilution. Figures indicate reciprocals of titres.

until no more agglutinins against the absorbing antigen could be demonstrated.

Agglutination tests were carried out in a 52° C. water-bath for 2 hr., using dilutions of serum in 0·85 per cent saline, and equal volumes of formalinized antigenic suspensions adjusted to approximately 1×10^9 bacilli per ml. The final serum dilutions ranged from 1/10 to 1/5120.

Comparison of the reactions before and after absorption shows that although *a* and *z* bear no direct antigenic relationship to each other, they each contain a fraction in common with z_{35} (Table 1).

The *z* complex can also be subdivided into two types, each of which has a specific factor and a factor common to both types, which includes the component shared with z_{35}.

Cross-absorption tests with z_{35} of *S.* cairina confirmed that it was not completely identical to z_{35} of *S.* chittagong, but showed that it shared the same factors with *a* and *z*.

Cultures of all *z*-containing *Salmonellae* described in the Kauffmann–White scheme were acquired from the National Collection of Type Cultures in London, or from the International Salmonella Centre in Copenhagen. Each culture was tested against specific factor sera prepared by saturating *z* (poona) and *z* (bulawayo) antisera with their heterologous antigens. All the cultures were agglutinated by one or other of the specific sera, thus forming two distinct groups (Table 2). It is of interest that the majority of the z_b group originated in central and southern Africa, including three first described from these laboratories (*S.* alexander, *S.* greenside, and *S.* rand).

Table 2. *Salmonellae* containing the Antigen *z*

z_p factor	z_b factor
S. bristol	*S.* alexander
S. businga	*S.* angola
S. clerkenwell	*S.* bulawayo
S. entebbe	*S.* carno
S. ezra	*S.* detroit
S. homosassa	*S.* greenside
S. indiana	*S.* haarlem
S. kaolack	*S.* nachshonim
S. kiambu	*S.* nordenham
S. poona	*S.* rand
S. preston	*S.* tosamanga
S. schoeneberg	
S. shubra	
S. sundsvall	
S. worthington	

Table 3. Relationships between the Flagellar Antigens *a* and z_{35}

Agglutinable suspensions	Antisera			
	(a_2) *S.* miami absorbed with *S.* durban	(a_3) *S.* miami absorbed with *S.* paratyphi A.	(a_4) *S.* paratyphi A. absorbed with *S.* miami	*S.* paratyphi A. absorbed with *S.* chittagong
S. paratyphi A. (a_1,a_2,a_3,a_4)	160	0	40	2,560
S. durban (a_1,a_3)	0	40	0	640
S. miami (a_1,a_2,a_3)	320	80	0	640
S. chittagong (z_{35})	0	0	0	0

le Minor[4] has shown that the *a* antigen is a complex one, divisible into four components, of which *S.* paratyphi A. possesses three (a_1, a_2, and a_4). Further tests were now undertaken to see which, if any, of these factors was the one shared with z_{35}.

The results (Table 3) confirm le Minor's findings, and show that the antigen shared with z_{35} is a part of the a_1 fraction. This is proved by the inagglutinability of z_{35} in specific factor sera for a_2, a_3, and a_4, and by the fact that an *a* antiserum (*S.* paratyphi A.), after absorption with z_{35}, still contains agglutinins for the antigens of *S.* paratyphi A., *S.* miami, and *S.* durban.

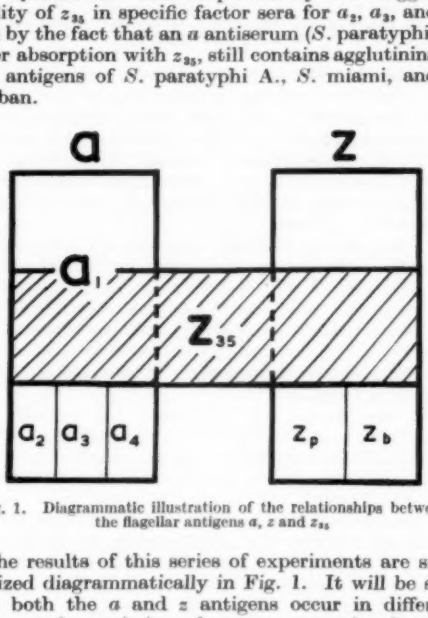

Fig. 1. Diagrammatic illustration of the relationships between the flagellar antigens *a*, *z* and z_{35}

The results of this series of experiments are summarized diagrammatically in Fig. 1. It will be seen that both the *a* and *z* antigens occur in different forms, each consisting of a common major fraction and one or more specific minor fractions. z_{35} shares one component with part of a_1, and a different component with part of the major fraction of *z*.

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VIROLOGY

Antigenic Structure of Non-Infectious Adenovirus Materials

HeLa cells infected with adenovirus type 5 produce, in addition to virus particles, three non-infectious materials previously named antigens *A*, *B* and *C*[1]. These antigens can be separated by electrophoresis[1] and by chromatography on diethylaminoethyl cellulose columns[2]. Antigen *B* corresponds to the protein factor responsible for the early cytopathic action of adenoviruses in HeLa cell cultures[3,4] and possibly also to the cell-detaching factor described by Rowe *et al.*[5]. Antigens *A* and *C*, but not antigen *B*, contain deoxyribonucleic acid[6]. A comparison of these three antigens by gel-diffusion precipitation tests revealed a partial identity of antigens *B* and *C* and absence of antigenic relationship of either of these two materials with antigen *A* [2].

In the present investigation, an attempt was made to establish more precisely the relationship between antigens *B* and *C*. The virus material used was obtained from HeLa cells infected with the prototype strain of adenovirus type 5. A partially purified antigen was prepared by treatment of the infected cells with the fluorocarbon compound 'Arcton 63' (Imperial Chemical Industries, Ltd., London, S.W.1) as described by Pereira and Valentine[7]. Chromatographic fractionation was carried out on diethylaminoethyl cellulose columns at *p*H 6·5, using stepwise elution with sodium chloride concentrations varying from 0·01 to 0·35 *M* in 0·05 *M* steps. The antiserum used throughout was from a rabbit immunized with the unfractionated virus material.

The complex nature of antigen *B* was first suggested by the fact that digestion of this antigen by 0·1 per cent crystalline trypsin at *p*H 7·4 for 1 hr. at 37° C. resulted in complete abolition of its cytopathic action for HeLa cells while its complement-fixing activity remained practically unchanged. The effect of trypsin on the behaviour of antigen *B* in gel-diffusion precipitation tests was next investigated. The results of a representative test are shown diagrammatically in Fig. 1. The reaction between antiserum and unfractionated antigen gives three precipitation lines corresponding to antigens *A*, *B* and *C* as indicated. Antigen *B* isolated by chromatography gives a single precipitation line continuous with the corresponding line of the original antigen and showing reactions of partial identity with antigen *C* and of non-identity with antigen *A*. After trypsin digestion, the same antigen *B* preparation gives a single precipitation line showing reactions of identity with antigen *C* and non-identity with antigen *A*. This result suggests that antigen *B* is a complex of a trypsin-sensitive protein with the trypsin-resistant antigen *C*.

This suggestion is supported by chromatographic studies shown in Fig. 2. The upper curve in this figure shows the fractionation of the original virus material into three antigenic components previously shown by Klemperer and Pereira[2] to correspond to antigens *A*, *B* and *C* with elution peaks at 0·275, 0·15 and 0·05–0·075 *M* sodium chloride respectively. The two eluates with highest complement-fixing titres in the band corresponding to antigen *B*, namely, the 0·15 and 0·175 *M* eluates, were pooled and divided into two equal parts, one of which was digested by trypsin under the conditions mentioned above. Both

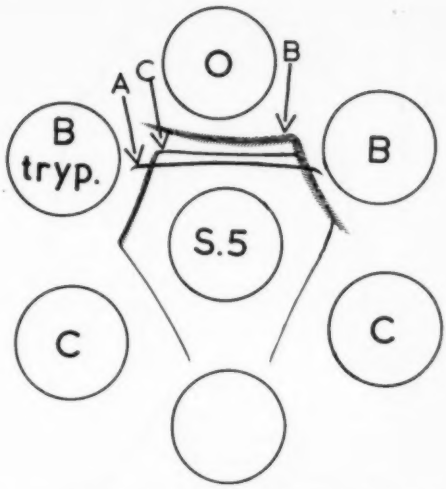

Fig. 1. Gel-diffusion precipitation test between adenovirus type 5 antiserum (*S* 5) and homologous antigens. *O*, Unfractionated antigen; *B*, antigen *B* isolated by chromatography; *B* tryp., the same antigen *B* preparation digested by trypsin; *C*, antigen *C* isolated by chromatography

parts were dialysed against 0·01 *M* phosphate buffer at *p*H 6·5 and re-chromatographed under the same conditions as those used for the original antigen. Complement-fixation titres of the eluates are shown in the middle and lower curves of Fig. 2 for untreated and trypsinized materials respectively. The untreated antigen was eluted essentially in a single band with a peak at 0·2 *M* sodium chloride. The difference in position of this elution band as compared with that of the corresponding antigen in the original run is difficult to understand; it could be due to displacement effects caused by antigens or other components present in the starting material. The trypsinized antigen, in contrast, was eluted at lower concentrations of sodium chloride, with a peak corresponding closely in position to that of antigen *C* in the original run.

The nature of the antigenic component common to antigens *B* and *C* was further investigated by staining the gel-diffusion precipitation lines with acridine orange following the technique developed by Allison and Armstrong[8]. It had been previously shown by this technique[6] that antigen *C* present in unfractionated virus materials was stained by acridine orange, giving a strong yellow-green fluorescence; this indicates the presence of deoxyribonucleic acid in this antigen. No such staining reaction was, however, obtained with precipitation lines of antigen *B*. Identical results were obtained with antigens fractionated by chromatography, and no deoxyribonucleic acid could be detected by this method either in untreated or in trypsinized antigen *B*. The antigenic component common to antigens *B* and *C* is shown, therefore, to be free of deoxyribonucleic acid.

For convenience, we will designate the trypsin-sensitive component of the *B* complex as antigen β and the trypsin-resistant component common to *B* and *C* as antigen γ. The antigenic factor so far identified in *A* will be designated antigen α. The various components of non-infectious adenovirus type 5 antigens are shown in Table 1. It should be pointed out that the components listed there may account

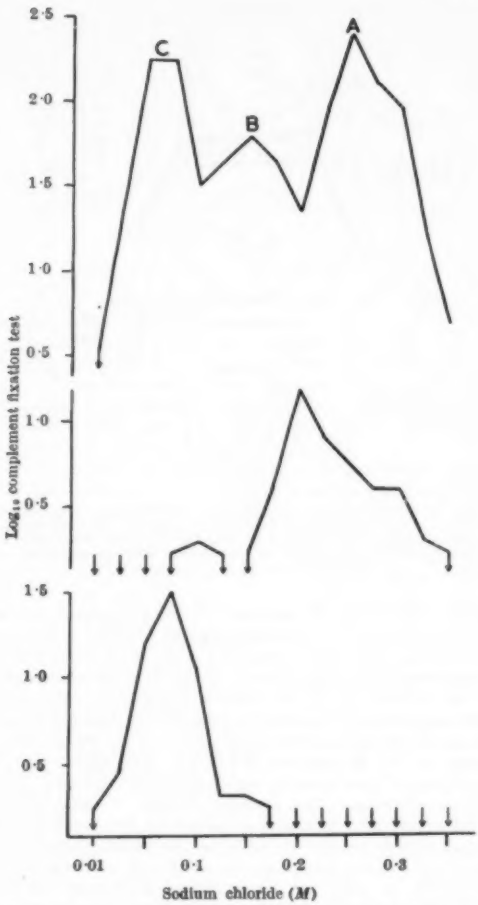

Fig. 2. Chromatography of adenovirus type 5 antigens on '*DEAE*-cellulose' columns. Stepwise elution with increasing concentrations of sodium chloride at constant *p*H (6·5). Eluates tested by complement fixation against adenovirus type 5 antiserum. Top curve, original virus material; middle curve, rechromatography of antigen *B* fractions (0·15 and 0·175 *M* eluates); lower curve, same as above, rechromatographed after trypsin digestion

for only part of the structure of antigens *A*, *B* and *C*. It is possible that the deoxyribonucleic acid components of antigens *A* and *C* may be nucleoproteins rather than pure deoxyribonucleic acid. This or additional factors not detected by the methods used in the present study might explain some anomalies apparent in the chromatographic behaviour of the antigens studied. A complex of antigen γ with deoxyribonucleic acid would be expected to elute from diethylaminoethyl cellulose at higher molarities than a complex of the same γ with another protein. The fact that antigen *C* is eluted from the columns before antigen *B* (Fig. 2) suggests, therefore, a higher complexity of the system.

The present findings might help to explain the possible relations of the antigens under study with virus particles and with the protein crystals free of deoxyribonucleic acid observed by Leuchtenberger and Boyer[9] and by Morgan *et al.*[10] in nuclei of HeLa cells infected with adenovirus type 5. It is tempting to speculate, for example, that complexes of antigen γ with nucleic acid or nucleoprotein would tend to aggregate to form virus particles whereas complexes of the same antigen with protein β would form the protein crystals free of deoxyribonucleic acid.

Table 1. Components Identified in Non-infectious Adenovirus Type 5 Antigens

Antigen	Component
A	α deoxyribonucleic acid
B	γ β
C	γ deoxyribonucleic acid

I am indebted to Drs. A. C. Allison, H. G. Klemperer and R. Porter for valuable suggestions and criticism.

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SOIL SCIENCE

Capillary Movement of Nitrate towards Tropical Soil Surfaces

As in many other parts of the tropics, accumulation of nitrate in the top inch of soil during the dry season has been observed at Katherine, Northern Territory, Australia, on a red sandy clay loam. The accumulation could be caused by a complex of processes of a physico-chemical, photo-chemical, biological or physical nature. Experiments at Katherine have shown that capillary movement has been obscured, rather than overlooked, as the main cause.

During the 1959 dry season, changes in chloride and nitrate content in the top soil of a clean fallow were followed in the 0–1, 1–2, 2–3, 3–6, 6–9 and 9–12 in. layers from April 20 onwards, that is, one day after the last rain in April. Normally, the rains end in April and are followed by a five-months rainless period. However, in 1959, 0·95 in. fell between May 18 and 24.

Chloride was applied to the soil surface on March 2 in the form of sodium chloride at the rate of 2,000 lb./acre. Leaching of this ion by the subsequent 13 in. of rain resulted on April 20 in a chloride distribution over the top 12 in. of soil as is given in Fig. 1. Comparative fallow plots receiving no salt were sampled for nitrate. Its distribution over the top 12 in. on the first sampling date is given in Fig. 2.

The progress of accumulation of chloride and nitrate near the soil surface is shown in Figs. 1 and 2. Chloride content in the top inch increased significantly from 950 p.p.m. on April 20 to 2,977 p.p.m. chloride on June 22, and nitrate significantly from 38 to 229 p.p.m. nitrate over the same period. Chloride content at this level decreased temporarily after the rain in May, but increased again in the following dry weather. Nitrate content in the top inch did not

decrease after the May rain, due presumably to a short period of nitrification at adequate moisture content, but showed a concentration pattern similar to that of chloride in the 12 in. profile throughout the sampling period.

More detailed sampling of the top $1\frac{3}{4}$ in. of the soil, in $\frac{1}{4}$ in. layers, revealed that the level of maximum accumulation is not at the surface but at a depth determined by the bottom of the soil crust. At this level the soil has an open and loose structure, and below it the soil is hard and compacted. A typical

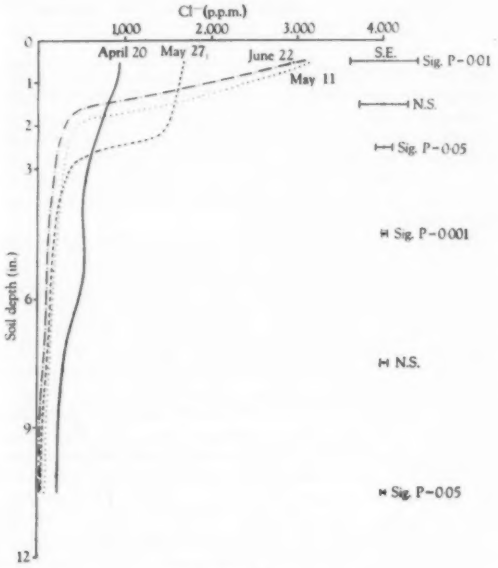

Fig. 1

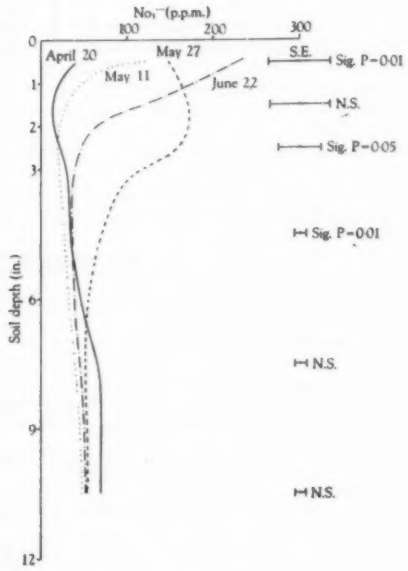

Fig. 2

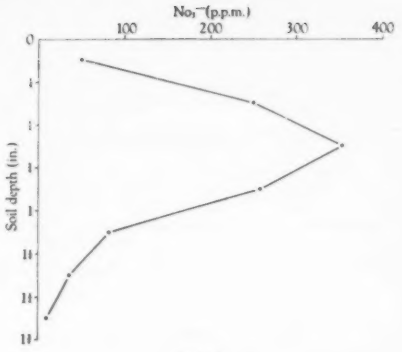

Fig. 3

nitrate stratification in the top $1\frac{3}{4}$ in. of the soil, measured in August at one point, is given in Fig. 3. The level of maximum nitrate accumulation has consistently been found to coincide with the bottom of the soil crust and is not related to actual soil depth. Chloride accumulation shows an exactly similar relationship with the crust.

This relationship and the fact that nitrate and chloride stratifications are affected in similar ways by rain and a following dry period indicate strongly that the main cause of nitrate accumulation near the surface of the soil is a physical one, for which capillary movement is the only acceptable explanation.

Further details will be published elsewhere.

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Complexes of Calcium-Montmorillonite with Polymers

Various types of polymers have been used to stabilize soil crumbs[1–5], the polymers linking together the domains of clay crystals within the crumbs[6]. To obtain further information on the nature of clay–polymer bonds, the interaction of calcium-montmorillonite with a wide range of polymers has been studied.

A neutral suspension of calcium-montmorillonite in 2×10^{-3} *M* calcium chloride was prepared from the $< 2\mu$ fraction of Wyoming bentonite (Volelay). To an aliquot of this suspension a known amount of organic material was added as a neutral solution. The calcium chloride present ensured that complexes formed rapidly after mixing, large flocs appearing within a few seconds. The clay was then filtered through a sintered glass funnel and later dried over phosphorus pentoxide to form an orientated disk 0·02 mm. thick.

Flakes about 4 mm. square were cut from the disk and their thickness measured with a travelling microscope reading to 0·002 mm. The swelling of the flake was determined after immersion in *M* calcium chloride and then in progressively more dilute calcium chloride solutions. The effect of adding 1·0 per cent of various materials on the swelling of calcium-montmorillonite is shown in Fig. 1, the ordinate being the ratio of the increase in thickness of the

Table 1. EFFECT OF LEACHING ON THE DISPERSION OF CALCIUM-MONTMORILLONITE COMPLEXES

Leaching treatment	Dispersion medium	Addition			
		None	1·0 per cent		
			Group 1	Group 2	Group 3
			Sodium alginate Sodium pectinate Sodium carboxy-butyl cellulose Sodium humate (from soil)	Sodium polyacrylate Polyacrylamide	Polyvinyl alcohol Polyglucosans Polyfructosans
N sodium chloride	*N*/100 sodium chloride	Dispersed in 2–3 hr.	Dispersed in 2–3 hr.	No dispersion	No dispersion
Neutralized 0·15 *M* sodium pyrophosphate	*N*/10 sodium chloride	Dispersed in 2–3 hr.	Dispersed in 2–3 hr.	Dispersed in 2–3 hr.	No dispersion

flake $(h - h_0)$ to its initial thickness (h_0) over phosphorus pentoxide.

The expansion of the clay in *M* calcium chloride is predominantly intra-crystalline, the d_{001} spacing increasing from 10·0 Å. (over phosphorus pentoxide) to 18·9 Å. In the more dilute calcium chloride solutions the swelling of the untreated clay is due to increasing separation of the clay crystals, as the d_{001} spacing in water is almost unchanged at 19·2 Å. A similar spacing in water has been reported previously[7–9]. As shown in Fig. 1, the inter-crystalline expansion was prevented by the addition of 1 per cent of cetyltrimethyl ammonium bromide or polyvinyl alcohol and largely suppressed by the same quantity of sodium alginate or polyacrylamide. Of these materials, cetyltrimethyl ammonium bromide, an organic cation and polyvinyl alcohol have been found to react with the basal surfaces of montmorillonite, for with increasing concentration they penetrate between the individual silicate sheets forming inter-lamellar complexes[10,11].

The similarity in the swelling pattern of the various complexes suggests that all four materials are reducing the expansion of the clay by linking together the basal surfaces of the clay crystals.

Further information on the nature of the clay–polymer bonds was obtained by trying to replace the exchangeable calcium ions on the clay by sodium ions. Flakes of calcium-montmorillonite with and without 1·0 per cent of polymer added were leached with *N* sodium chloride or 0·15 *M* sodium pyrophosphate adjusted to *p*H 7·0. Afterwards, the behaviour of the flakes was observed in dilute sodium chloride solutions. The results for a range of polymers are given in Table 1. Dispersion of the clay plus polymer flake at the same concentration of sodium chloride as the untreated clay indicates that the polymer has been removed.

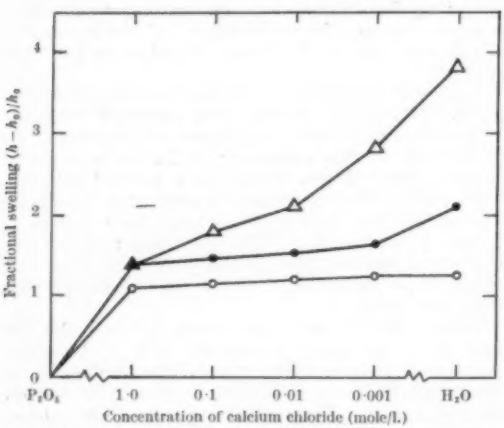

Fig. 1. Swelling of calcium-montmorillonite complexes. △, Calcium-montmorillonite, untreated; ●, calcium-montmorillonite plus 1 per cent sodium alginate, polyacrylamide; ○, calcium-montmorillonite plus 1 per cent polyvinyl alcohol, cetyltrimethyl ammonium bromide

The polymers have been divided into three groups according to their ease of displacement. Polymers of group 1 were readily removed by *N* sodium chloride. This indicates that the complexes were formed by precipitation with the exchangeable calcium ions near the basal surfaces of the clay crystals. The second group was only removed by a strong solution of sodium pyrophosphate. From this, it is inferred that the polymers formed co-ordination compounds with the exchangeable calcium ions, but that these calcium ions could be displaced by a strong sequestering agent. The remaining group of polymers was unaffected by either treatment. Here, the bonding, therefore, is independent of the valency of the exchangeable cation. It is inferred that these polymers are linked by a series of hydrogen bonds between the polymer hydroxyl groups and the surface oxygens of the silicate sheets.

The complex with humic acid extracted from soil is of interest. Previously it has been shown that the clay in soil crumbs from old grassland is still held together after leaching with neutralized sodium pyrophosphate[12]. It follows from the above results that although humic acid can link clay crystals together, it is too easily removed to be the important polymer in soil organic matter for stabilizing soil crumbs.

I wish to thank Dr. K. Norrish for determining the X-ray spacings and Dr. R. Swaby for the sample of humic acid.

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FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, May 16

UNIVERSITY OF LONDON (at the Wright-Fleming Institute of Microbiology, St. Mary's Hospital Medical School, Norfolk Place, London, W.2), at 5 p.m.—Prof. R. R. Porter: "The Structure of Gamma Globulin and Antibodies". (Third of four Almroth Wright Lectures. Further lecture on May 23.)

BRITISH SOCIETY FOR THE PHILOSOPHY OF SCIENCE (in the Joint Staff Common Room, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Dr. Marjorie Grene: "Adaptation and Evolution".

ROYAL SOCIETY OF ARTS (at John Adam Street, Adelphi, London, W.C.2), at 6 p.m.—Mr. F. H. S. Brown: "The Power System". (Second of Three Cantor Lectures on "Energy".)

Tuesday, May 17

LONDON SCHOOL OF ECONOMICS AND POLITICAL SCIENCE (at Houghton Street, Aldwych, London, W.C.2), at 5 p.m.—Prof. C. H. Waddington, F.R.S.: "Evolutionary Wisdom and Ethical Value"* (Fourth Auguste Comte Memorial Lecture).

ROYAL AERONAUTICAL SOCIETY, HISTORICAL GROUP (at the Institution of Mechanical Engineers, 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Sir Thomas Sopwith, C.B.E.: "My First Ten Years" (Inaugural Lecture).

Wednesday, May 18

INSTITUTION OF ELECTRICAL ENGINEERS (at the Institution of Civil Engineers, Great George Street, Westminster, London, S.W.1), at 10 a.m.—Symposium on "Electronic Equipment Reliability—Field Experience and Methods of Assessing and Predicting Reliability".

ROYAL METEOROLOGICAL SOCIETY (at 49 Cromwell Road, London, S.W.7), at 5 p.m.—Mr. F. K. Hare: "The Summer Circulation of the Arctic Stratosphere Below 30 km."; Mr. J. I. P. Jones and Mr. F. Pasquill: "An Experimental System for Directly Recording Statistics of the Intensity of Atmospheric Turbulence"; Mr. J. L. Monteith: "The Reflection of Short-Wave Radiation by Vegetation".

WOMEN'S ENGINEERING SOCIETY (at "Hope House", 45 Great Peter Street, London, S.W.1), at 7 p.m.—Miss R. Winslade: "Electronic Weighing".

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 9 p.m.—Dr. David Lack, F.R.S.: "A Survey of the Conflict Between Evolution Theory and Christian Belief".

Thursday, May 19

INSTITUTION OF MINING AND METALLURGY (at the Geological Society of London, Burlington House, Piccadilly, London, W.1), at 4 p.m.—Annual General Meeting. Prof. David Williams: "Progress in Mining Geology—Education Research and Employment" (Presidential Address).

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Mr. J. M. Aronson and Prof. R. D. Preston, F.R.S.: "An Electron Microscope and X-ray Analysis of the Walls of Selected Lower Phycomycetes"; Mr. H. G. Callan and Mr. L. Lloyd: "The Lampbrush Chromosomes of Crested Newts *Triturus cristatus* (Laurenti)".

INSTITUTION OF ELECTRICAL ENGINEERS (at Savoy Place, London, W.C.2), at 5.30 p.m.—Annual General Meeting, followed by Dr. A. M. Spooner: "Technical Features of a [New Television Studio at Wembley".

ROYAL AERONAUTICAL SOCIETY (at the Institution of Mechanical Engineers, 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Dr. M. J. Lighthill, F.R.S.: "Mathematics and Aeronautics" (48th Wilbur Wright Memorial Lecture).

ROYAL SOCIETY OF TROPICAL MEDICINE AND HYGIENE (at Manson House, 26 Portland Place, London, W.1), at 7.30 p.m.—Dr. G. S. Nelson: "Schistosomes as Zoonoses in Africa".

BRITISH INSTITUTE OF RADIOLOGY (in the Reid-Knox Hall, 32 Welbeck Street, London, W.1), at 7.30 p.m.—Annual General Meeting. 8 p.m.—Dr. V. E. Cosslett: "X-Ray Microscopy—Retrospect and Prospect" (Thirty-ninth Silvanus Thompson Memorial Lecture).

Friday, May 20

ROYAL SOCIETY OF MEDICINE, EPIDEMIOLOGY AND PREVENTIVE MEDICINE and COMPARATIVE MEDICINE SECTIONS (at 1 Wimpole Street, London, W.1), at 5.30 p.m.—Discussion on "Myxomatosis in Britain". Speakers: Dr. C. H. Andrewes, Mr. H. V. Thompson and the Hon. Miriam Rothschild.

Friday, May 20—Saturday, May 21

BRITISH SOCIETY FOR IMMUNOLOGY (in the Hall of the London Hospital Medical College, Ashfield Street, London, E.1)—Spring Meeting.

Friday, May 20

At 10 a.m.—Symposium on "Immunological Aspects of Diseases of Connective Tissue". Chairman: Dr. L. E. Glynn.

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ASSISTANT LECTURER (with special qualifications in palæontology) IN GEOLOGY—The Secretary, The University, Belfast (May 20).

ASSISTANT LECTURER IN ZOOLOGY—The Registrar, The University, Manchester 13 (May 21).

LECTURER IN THE DEPARTMENT OF NATURAL PHILOSOPHY—The Secretary, The University, Edinburgh (May 21).

EXPERIMENTAL PHYSICIST to work for a D.Phil. degree on high temperature physics, plasma physics, ionization in gases or nuclear gas reactions at very low kinetic energy—T. C. Keeley, Esq., C.B.E., M.A., The Clarendon Laboratory, The University, Parks Road, Oxford (May 21).

READERS IN NUCLEAR PHYSICS; MATHEMATICS (preferably Mathematical Physics); MATHEMATICS (Electronic Digital Computers); and CHEMICAL ENGINEERING—The Bursar, College of Advanced Technology, Gosta Green, Birmingham 4, quoting "D" (May 21).

LECTURER (Grade II) IN STATISTICS within the Department of Mathematics—The Registrar, The University, Bristol (May 23).

READER (with outstanding research ability) IN PHYSICS; a SENIOR LECTURER (with a good honours degree together with research and/or industrial experience, and preferably an interest in nuclear physics) IN PHYSICS; and an ASSISTANT LECTURER, Grade "B" (with a good honours degree) IN PHYSICS—The Registrar, Royal Technical College, Salford 5, Lancs (May 23).

TECHNICAL OFFICER (with a specialized knowledge of optical design and appropriate experience, and preferably mathematics and physics to G.C.E. "O" level) IN OPTICAL DESIGN, at the Weapons Research Establishment, Salisbury, South Australia, to be responsible for the design of optical lenses and systems, under the general guidance of the professional staff—Senior Representative (AV. 60/3), Department of Supply, Australia House, Strand, London, W.C.2 (May 23).

INSTRUMENT TECHNICIAN (Experimental Officer grade, with H.N.C. or equivalent), for the development, adaptation and maintenance of instruments used by research departments—The Secretary, Glasshouse Crops Research Institute, Worthing Road, Rustington, Littlehampton, Sussex (May 24).

KEEPER IN BOTANY (with a good honours degree in botany and/or a Museums Diploma, and preferably museum experience)—The Director, Liverpool Public Museums, Carnatic Hall, Elmswood Road, Liverpool 18 (May 24).

LECTURER, Grade II, IN CHEMICAL PHYSIOLOGY—The Registrar and Secretary, The University, Bristol (May 24).

NEMATOLOGIST; and a GENETICIST (Plant Breeder) (Scientific Officer grade, with an honours degree in an appropriate scientific subject, and preferably postgraduate experience)—The Secretary, Glasshouse Crops Research Institute, Worthing Road, Rustington, Littlehampton, Sussex (May 24).

ASSISTANT EXPERIMENTAL OFFICER (graduate, with a degree in zoology and/or botany and an interest in biochemistry, also those graduating in 1960 considered) IN THE NEMATOLOGY DEPARTMENT—The Secretary, Rothamsted Experimental Station, Harpenden, Herts (May 28).

ASSISTANT LECTURER IN PHILOSOPHY—The Registrar, University College of Wales, Aberystwyth (May 30).

ASSISTANT LECTURER (preferably with a special interest in inorganic chemistry) IN CHEMISTRY—The Secretary, Birkbeck College (University of London), Malet Street, London, W.C.1 (May 30).

ASSISTANT LECTURERS (2) IN PHYSICS—The Principal, Royal Holloway College, Englefield Green, Surrey (May 31).

CHAIR OF BOTANY—Joint Clerk to the University Court, The University, St. Andrews (May 31).

FELLOW, for research on factors influencing flowering and seed production in herbage grasses—The Registrar (Room 22, O.R.B.), The University, Reading (May 31).

LECTURER or SENIOR LECTURER IN GENETICS AND PLANT BREEDING; an ASSISTANT LECTURER IN BOTANY; and a DEMONSTRATOR IN ZOOLOGY in the Department of Biological Sciences—The Registrar, Wye College (University of London), near Ashford, Kent (May 31).

RESEARCH ASSISTANT (preferably candidate with either a degree in geology with good subsidiary zoology or a good degree in zoology with subsidiary geology) IN VERTEBRATE PALÆONTOLOGY IN THE DEPARTMENT OF GEOLOGY—The Registrar, King's College (University of Durham), Newcastle upon Tyne 1 (May 31).

ESSO RESEARCH FELLOW IN PHYSICAL CHEMISTRY, to work in the field of heterogeneous catalysis—The Registrar, The University, Nottingham (June 1).

RESEARCH FELLOW (post-doctoral chemist or biochemist) IN THE DEPARTMENT OF CHEMISTRY of the Faculty of Science, to take part in work on the synthesis of nucleotide analogues and the study of their metabolism—The Registrar, The University, Manchester (June 1).

ASSISTANT DIRECTOR OF GRADUATE STUDIES IN THE DEPARTMENT OF PHYSICAL CHEMISTRY—The Registrar, The University, Leeds 2 (June 7).

ASSISTANT LECTURER or LECTURER (with special qualifications in pure mathematics) IN MATHEMATICS—The Registrar (Room 22, O.R.B.), The University, Reading (June 7).

BOTANIST, Scientific Officer grade (with a good honours degree and preferably postgraduate training or research experience), to study the development and anatomy of apples in relation to storage behaviour—The Secretary, East Malling Research Station, near Maidstone, Kent (June 11).

PLANT PHYSIOLOGIST (honours graduate in science or agricultural science with appropriate postgraduate research experience) IN THE DIVISION OF PLANT INDUSTRY, Commonwealth Scientific and Industrial Research Organization, Canberra, A.C.T., Australia, to initiate studies on the physiology of growth in pastures and pasture plants with the ultimate aim of understanding more fully the determination of pasture yield—Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting Appointment No. 130/418 (June 11).

SENIOR LECTURER (with research experience) IN PHYSIOLOGY at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, June 11).

ASSOCIATE PROFESSOR IN MATHEMATICS; a SENIOR LECTURER or LECTURER IN MATHEMATICS; a SENIOR LECTURER or LECTURER IN STATISTICS; a SENIOR LECTURER or LECTURER IN BOTANY; a SENIOR LECTURER or LECTURER IN CHEMISTRY; a SENIOR LECTURER or LECTURER IN GEOLOGY; a SENIOR LECTURER or LECTURER IN PHYSICS; and a SENIOR LECTURER or LECTURER IN ZOOLOGY at Canberra University College, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, June 15).

LECTURER (graduate in science, preferably with honours in physiology, or with a higher degree, or graduate in medicine or veterinary science, and preferably with experience in research in, or teaching of, physiology) IN PHYSIOLOGY at the University of Queensland, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, June 15).

LECTURER IN THE DEPARTMENT OF CHEMICAL ENGINEERING, University of the Witwatersrand, Johannesburg, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa and London, June 15).

SENIOR LECTURER IN PHYSICS; LECTURER IN PHYSICS; LECTURERS (2) IN CHEMISTRY; a LECTURER IN CIVIL ENGINEERING; and LECTURERS (2) IN MATHEMATICS at the University of Auckland, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand and London, June 15).

LECTURER and a SENIOR LECTURER IN APPLIED MATHEMATICS at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, June 18).

LECTURER (honours graduate in either physics or electrical engineering, and preferably with an interest in audiofrequency acoustics associated with human communication) IN ACOUSTICS IN THE DEPARTMENT OF PHYSICS—The Registrar, The University, Liverpool, quoting Ref. No. CV/N (June 18).

SENIOR LECTURER or LECTURER IN PHYSICS at the University of Otago, Dunedin, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand and London, June 18).

LECTURER (qualified and interested in any of the following research topics: solid state studies, X-ray spectrography of solids and gases, radio investigations of the upper atmosphere such as meteorite distribution, auroral zone detection and studies of the lower ionosphere); and an ASSISTANT LECTURER (with an honours degree in physics) IN THE DEPARTMENT OF PHYSICS, University of Canterbury, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand and London, June 30).

SENIOR TECHNICIAN IN THE DEPARTMENT OF PHYSIOLOGY; and a SCIENTIFIC INSTRUMENT MECHANIC, to take charge of the Faculty of Science Workshop, Makerere College, The University College of East Africa—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (June 30).

MENTAL HEALTH RESEARCH FUND FELLOWS (suitably qualified persons wishing to pursue full-time research work bearing on problems of mental health, whether in clinical psychiatry, or one of its supporting sciences)—The Secretary, Research Committee, Mental Health Research Fund, 39 Queen Anne Street, London, W.1 (October 1).

BIOCHEMIST, Basic grade (graduate in chemistry or Associate or Graduate Member of the Royal Institute of Chemistry), IN THE DEPARTMENT OF PATHOLOGY—The Group Secretary, Queen Elizabeth Hospital for Children, Hackney Road, London, E.2.

BIOCHEMIST, or an ORGANIC or PHYSICAL CHEMIST (university graduate with first- or second-class honours), to work at Millport on organic matter in sea water in its relation to marine organisms—The Director, Scottish Marine Biological Association, Marine Station, Millport, Isle of Cumbrae, Scotland.

BIOCHEMIST (Senior or Basic grade), to the Rochdale Group of Hospitals, to work under the Consultant Pathologist and to carry out biochemical work for the hospitals and clinics of the Group—The Group Secretary, Rochdale and District Hospital Management Committee, Central Offices, Birch Hill Hospital, Rochdale, Lancs.

HEAD (medical graduate or science graduate with a higher degree) OF THE DIVISION OF VIROLOGY, for duties which will include the supervision of diagnostic services and the carrying out of special investigations on, and research into, virus diseases—The Director, Institute of Medical and Veterinary Science, P.O. Box 14, Rundle Street, Adelaide, South Australia.

LECTURER (male, single, preferably specializing in entomology and/or animal physiology) IN AGRICULTURAL ZOOLOGY and ASSISTANT WARDEN—The Clerk to the Governors, Essex Institute of Agriculture, Writtle, near Chelmsford.

LECTURER (with a good honours degree in mathematics with teaching and/or industrial and research experience) IN MATHEMATICS—The Clerk to the Governors, South-East Essex Technical College, Longbridge Road, Dagenham, Essex.

RESEARCH ASSISTANT (man or woman) IN ZOOLOGY, to assist Prof. T. A. Stephenson, F.R.S., with the completion of a book on the seashore ecology of the world—The Registrar, University College of Wales, Aberystwyth.

SENIOR LECTURER and a LECTURER (with an honours degree in physics, industrial and/or research experience in some branch of applied physics, and teaching experience) IN THE DEPARTMENT OF PHYSICS—The Registrar, College of Science and Technology, Ashley Down, Bristol 7.

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REPORTS and other PUBLICATIONS

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